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SPECIFICATION

No. LSP-340-6 Date: 2-24-64

SPACE SUIT ASSEMBLY
PERFORMANCE AND INTERFACE
SPECIFICATION [U]

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PRELIMINARY
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Grumman LEM

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SPACE SUIT ASSEMBLY

PERFORMANCE AND INTERFACE

SPECIFICATION

1 SCOPE

1.1 Scope. - This specification establishes the performance and interface requirements for the Government furnished Space Suit Assembly (SSA) to be used in the Lunar Excursion Module (LEM) of the Apollo Spacecraft in accordance with Exhibit A, NAS 9-723, and Exhibit B, NAS 9-1100.

2 APPLICABLE DOCUMENTS

2.1 Government Documents. - The following Government documents of the issue in effect on 14 January 1963, or as otherwise specified, form a part of this specification to the extent specified herein:

SPECIFICATIONS

NASA

Exhibit A, NAS 9-723	Project Apollo Space Suit Assembly Development, Statement of Work
Exhibits A and B, NAS 9-1100	Statement of Work, and Technical Approach, Lunar Excursion Module, Project Apollo
NPC 200-2	Quality Program Provisions for Space System Contractors

2.1 (Continued)

Military

MIL-V-27446(USAF)	Visor, Helmet, Optical, Characteristics, General Specification for
NW 13-10-501	Light Weight High Altitude Full Pressure Suit - Mark IV Mod 0

STANDARDS

Military

MIL-STD-202B	Test Methods for Electronic and Electrical Component Parts
MIL-STD-681	Identification Coding and Application of Hookup Wire
MIL-STD-704	Electrical Power, Aircraft Characteristics and Utilization of
MIL-STD-810	Environmental Test Methods for Aerospace and Ground Equipment

2.2 Grumman Documents. - The following Grumman documents of date of issue, form a part of this specification to the extent specified herein:

SPECIFICATIONS

LSP-390-001	Bonding, Electrical, General Specification for
LSP-530-001 with Amendment No. 1	Electromagnetic Interference, General Specification for

2.2 (Continued)

LEM Documents

LED-480-4 (to be released)	Human Engineering Criteria for the Lunar Excursion Module
LED-520-2	A Preliminary Analysis of Lunar Surface Models for LEM Landing
LED-520-3	Material Evaluation Procedures for LEM Crew Compartment

Reference Documents

SLE-13-63-427	Letter - J. L. Decker; NASA Contract NAS 9-1100, Meteoroid Environment
00.235 (NAS 9-1163)	Chance Vought Report: Comparative Evaluation of Thermal Protective Materials for Space Suit Assemblies

2.3 Availability of Documents. -

2.3.1 Government Documents. - Copies of Government documents may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D.C., 20402.

2.3.2 Grumman Documents. - Copies of this specification and other applicable Grumman documents may be obtained from LEM Program Data Management, Grumman Aircraft Engineering Corporation, Bethpage, Long Island, New York, 11714.

2.4 Precedence of Documents. - This specification shall govern when the requirements conflict with other documents referenced herein.

3 REQUIREMENTS

3.1 General. - The Space Suit Assembly (SSA) shall have the following major capabilities:

(a) Enable crew members to leave the LEM in free-space to perform corrective maintenance.

(b) Enable crew members to leave the LEM after a lunar landing to accomplish mission scientific and exploratory tasks, and required maintenance.

(c) Enable the crew members to have a short term emergency back-up protection against loss or shutdown of cabin pressure and, or minor LEM subsystem failures.

3.1.1 Crewman Mobility. - A crewman, wearing a complete SSA pressurized to 3.5 psia, shall be capable of the following:

(a) Ingress and egress unaided through either LEM passageway within 18 seconds (See Figure 10a). The elapsed time shall not include time to unlatch and open hatches. The time period shall be for a 90 percentile man carrying specified tools and equipment. Both passageways are primarily cylindrical in shape and their length and inside surfaces are shown in Figure 10a.

(b) Walk at rates up to 3 mph on slopes of a minimum of 3° with at least half being uphill slopes, for continuous periods of at least 10 minutes, carrying tools or equipment of a minimum of 100 earth pounds in lunar environment.

(c) Climb a 15 foot vertical ladder with rungs spaced 12 inches on centers, carrying a full complement of tools and equipment, within 72 seconds.

3.1.1 (Continued)

(d) Crouch in a deep knee bend for 3 minutes and kneel on one knee for 5 minutes.

(e) Manipulate the feet, hands, legs, forearms, arms, head, and torso as shown in Figure 6. Maximum torque values for body joints, such as ankles, knees, hips, waist, fingers, knuckles, elbows, shoulders and neck, are listed in Table III. The movements described shall not be limited to single successive actions, but shall be concurrent in as many cases as necessary to perform the operational duties.

(f) Rise from a supine position to a standing position unassisted within 30 seconds.

(g) Perform the required operation and maintenance tasks in, or outside the LEM.

(h) Manipulate the required tools and apparatus.

(i) Communicate with the other crewmen or the Deep Space Instrumentation Facility (DSIF) using the SSA communications system(s) via LEM relay.

(j) Make all necessary visual sightings and readings. (See paragraph 3.4.2)

3.1.1.1 Unpressurized Mobility. - A crewman wearing an unpressurized Pressure Garment Assembly sans gloves without Portable Life Support System, thermal garment, or extra-vehicular boots, and with face plate open, shall be capable of performance equivalent to a Navy Mark IV pressure suit (Refer to NW 13-10-501).

3.2 Major Components. - The Space Suit Assembly shall be a pressurized, closed circuit, anthropomorphic type and have the following major components as the minimum requirements:

(a) Constant Wear Garment (CWG)

(b) Pressure Garment Assembly (PGA)

3.2 (Continued)

(c) Thermal Garment

(d) Portable Life Support System (PLSS)

(e) Integrated Biomedical and Environmental Sensors

(f) Integrated Communications and Telemetry Equipment

(g) SSA Waste Management

(h) SSA Vomitus Management

3.2.1 Constant Wear Garment (CWG). - The CWG shall be worn by the crewman at all times in the Lunar Excursion Module (LEM). The garment shall have enough material mass and texture to retain the perspiration residual products without cake hardening for the entire mission. The CWG shall have a waffle knit, or similar absorbant hydrophilic material to permit capillary wicking of body moisture for evaporation. The garment shape shall conform to the body contours of the crewman without irritating, multilayer folds, and shall not be an inelastic snug fit which will bind or restrict the crewman.

3.2.2 Pressure Garment Assembly (PGA). - The major items of the PGA are a helmet, a torso and limb suit with lightweight boots, and a pair of gloves. The PGA, pressurized at 3.5 psia, shall permit the crewman to use portable lights, tools, cameras, patch kits, scientific instruments, equipment attachments and other accessories, and also meet the mobility requirements of paragraph 3.1.1. The PGA shall contain provisions for sealing air leaks and maintain pressure in the garment, meet the reliability requirements while performing the mobility tasks of the mission in paragraph 3.1.1 and the thermal requirements of paragraph 3.5.4. The total leakage rate is specified in paragraph 3.5.5.1.1. The PGA shall be worn during the entire LEM mission.

3.2.2.1 Helmet. - The helmet shall be an enclosure with the following features, pressurized at 3.5 psia and, or at ambient pressure:

(a) Protect the crewman's head against high impact loads of Table II to be encountered during lunar landing or rendezvous docking. (See axes in Figure 11.)

(b) Permit use of manual, mechanical or remotely operated optical navigation or other instruments.

(c) Contain provisions to reflect and, or, absorb intense or concentrated light rays. These provisions shall not be detrimental in weaker light sources. The helmet visor shall have the following minimum characteristics:

(1) Ultraviolet transmission shall be less than 0.5 percent average from 200 to 400 millimicrons.

(2) Infrared reflection of 90 percent average from 700 millimicrons to 1.2 microns.

(3) The visible transmission after processing shall not be less than 86 percent average from 429 to 675 millimicrons.

(d) Contain provisions for two microphones and two redundantly wired voice communication earphone assemblies to receive a signal level of 20 dbm from a balanced, 600 ohm impedance source. An isolation network shall be included to provide proper impedance matching between the source and each earphone, and also provide isolation of an electrical short circuit in one earphone from disabling the reception of the other earphone. The microphone assembly output shall be a nominal 600 ohm, balanced system, capable of providing

3.2.2.1 (d) (Continued)

0 dbm into 600 ohm when a normal conversational voice is applied to both microphones. The isolation-mixing network shall provide proper impedance matching between each amplifier and the output, and also provide isolation of a short in the output circuitry of one amplifier from disabling the output of the other amplifier.

(e) Permit the crewman, with head in a fixed position, to have a minimum horizontal field of vision of 195 degrees, and a minimum vertical field of vision of $\pm$ 62.5 degrees from the horizontal line of sight (LOS). The head and body movements shall not cause the suit to restrict the field of vision. The field of view shall remain fog or frost free for 24 hours at 0°F during operation with LEM-ECS (Environmental Control Subsystem), and 4 hours during operation with PLSS in lunar surface or free-space environment (Table I). The optical properties for view-through materials shall be in accordance with Specification MIL-V-27446(USAF).

(f) Provide for a minimum noise attenuation in the following bandwidths:

(1) 40 db at 2000 cps and above.

(2) 60 db from 500 to 2000 cps.

(3) 15 db at 500 cps or below.

(g) Permit the intake of food with the visor open.

(h) Provide adequate oxygen flow across the facial area to insure the availability of a fresh supply of pure oxygen, not recirculated gas, for breathing.

(i) The helmet shall have a positive locking fixture for attaching a removable light source with reflector. The attachment shall not interfere with the crewman's functional activities while wearing the helmet.

3.2.2.2 Torso and Limb Suit. - The torso and limb suit shall be an anthropomorphic pressure vessel covering the crewman's body and limbs, excluding the head and hands. The torso and limb suit shall contain provisions for accepting the helmet and gloves to complete the anthropomorphic pressure vessel enveloping the entire crewman. The required gas umbilical fittings shall be located and designed to preclude interference with the support and restraint system for the crewman. The suit design shall maintain maximum faceplate visibility as the crewman changes from erect, sitting, crouching, kneeling, supine or prone position. Attachments shall be included in areas accessible to obtain radiation dosimeter, suit pressure, oxygen quantities and elapsed time environmental sensor readings without interfering with the LEM restraint system. Capability of applying medical injections when the crewman is fully suited and the suit pressurized shall be provided. Provisions shall be incorporated to prevent loss of suit pressure if the gloves are punctured (See paragraph 3.5.5.1). The suit shall comply with the reliability requirements of paragraph 3.5.11, the leakage rate of paragraph 3.5.5.1.1, and the thermal requirements of 3.5.4.

3.2.2.2.1 Lightweight Boots (Intra-vehicular). - The lightweight boots shall have a sole and heel wearing surface for intra-vehicular walking, and provide support and protection of the pressurized PGA feet and additional thermal insulation.

3.2.2.3 Gloves. - The gloves shall have self-don and self-doff capabilities using a minimum of effort and time. The gloves shall meet the mobility and finger dexterity requirements of paragraph 3.1.1(e) to permit the use of required scientific, operational, and emergency equipment and tools for the LEM mission. The intra-vehicular gloves shall have a minimum insulation resistance of 1/2 clo. The extra-vehicular gloves when worn over the intra-vehicular gloves shall have a combined minimum insulation of 2 clo. The gloves shall be pressure sealed and constructed in accordance with the reliability requirements of paragraph 3.5.11.

3.2.3 Thermal Garment. - The major items of the Thermal Garment shall consist of a reflective or thermal coverall, extra-vehicular gloves, and extra-vehicular boots.

3.2.3.1 Thermal Coverall. - The thermal coverall shall be a loose fitting, self-donning coverall covering the PGA, excluding the helmet and gloves. The coverall shall consist of reflective surfaces and insulating materials, and shall be constructed in accordance with the thermal design in paragraph 3.5.4. The coverall shall maintain its reflective efficiency after moderate wrinkling. The coverall shall not exceed a heat leakage rate of ± 250 BTU/hr. The coverall materials shall resist the abrasive, or out-gassing, environment of free-space, ingress and egress through the LEM passages, the lunar surface, radiation levels and the meteoroids referenced in paragraphs 3.5.5.5 and 3.5.5.6. The thermal coverall shall not reduce the ability of the crewman to perform his mission. The coverall shall be capable of being self-donned in the LEM (See paragraph 3.5.9).

3.2.3.2 Extra-Vehicular Gloves. - The extra-vehicular gloves shall be worn over the PGA gloves to provide additional insulation from thermal transfer to meet the thermal design requirements of paragraphs 3.2.2.3 and 3.5.4, and additional radiation protection in accordance with paragraph 3.5.5.5. They shall resist the abrasive, or out-gassing, environment of free-space, ingress and egress through the LEM passages, the lunar surface, radiation levels and the meteoroids referenced in paragraphs 3.5.5.5 and 3.5.5.6. The gloves shall not restrict the crewman's dexterity to perform emergency and maintenance tasks, or to manipulate and erect mission task equipment. The gloves shall have self-don and self-doff capabilities inside or outside the LEM, and during environmental extremes to be encountered. A means shall be provided to retain and prevent loss of the gloves. The retentive means shall not be capable of ensnaring on projecting structures, equipment, or interfere with the restraint system.

3.2.3.3 Extra-Vehicular Boots. - The extra-vehicular boots shall have an insulating sole and reflective outer surface to meet the thermal design requirements of paragraph 3.5.4. The boots shall be comfortable for the crewman and not hinder walking, crouching or climbing. The boots shall be capable of being self-donned. The footprint area shall be a minimum of 60 square inches.

3.2.4 Portable Life Support System (PLSS). - The PLSS is a self-contained, portable, rechargeable system, providing limited-time life support for a crewman in the PGA exposed to extra-vehicular free-space, decompressed LEM, or lunar surface environment. It shall consist of a backpack transported "knapsack" fashion, and a separate emergency oxygen unit. The backpack shall provide the normal mode of operation and assist the emergency oxygen unit to support certain modes. The backpack envelope is given in Figure 7.

3.2.4.1 Backpack. - The backpack shall be composed of subsystem components to provide assistance or operating modes for:

(a) Storage of primary oxygen supply

(b) Contamination control

(c) Humidity control

(d) Pressure control

(e) Ventilation control

(f) Temperature control

(g) Recirculatory system

(h) Electrical power

(i) Voice communication (duplex)

3.2.4.1 (Continued)

(j) Telemetry transmission (duplex)

(k) Emergency voice communication (simplex) (Refer to paragraph 3.2.6.1.1)

3.2.4.1.1 Primary Oxygen Supply. - The supply of pure oxygen for the primary system shall be contained in a reservoir capable of supplying sufficient oxygen to satisfy the mission metabolic profile of paragraph 3.5.13, and the requirements of other SSA systems, in addition to a safety margin and ullage. The reservoir shall contain the oxygen under pressure to reduce its overall size and weight to fit inside the PLSS backpack. The reservoir shall contain provisions for discharging, recharging, and support to the backpack structure. Recharging within 10 minutes from an 850 psia oxygen supply at 20°F shall be possible to provide sufficient oxygen for a 4 hour excursion.

3.2.4.1.2 Contamination Control. - Contamination control shall provide a means to remove explosive, noxious, nauseous, or toxic gases, solid particles and excessive moisture from the suit recirculatory system, when the suit is pressurized. The means shall satisfy the mission profile demands including emergency conditions by recharging or replacing, or any method accepted by Manned Spacecraft Center (MSC) and Grumman.

3.2.4.1.3 Humidity Control. - Humidity control shall maintain a relative humidity (RH) of 40 to 70 percent within temperature range in paragraph 3.2.4.1.6 in the controlled normal and emergency environment of the pressurized suit. The means of accomplishment shall be subject to MSC approval and Grumman assent.

3.2.4.1.4 Pressure Control. - Normal pressure control shall be provided using the primary oxygen which shall maintain a steady operating pressure of 3.5 (+0.2, -0.0) psia. The minimum consecutive operation period shall be 3 hours nominal and one hour for contingencies. Emergency pressure shall be available using the emergency

3.2.4.1.4 (Continued)

oxygen which shall provide a steady pressure of 3.5 psia for a minimum consecutive operation time of 5 minutes as a result of the following:

(a) Backpack not available

(b) Primary oxygen not available

(c) PGA pressure relief valve failed in open position

(d) PGA leakage equivalent to the maximum relief valve opening.

3.2.4.1.5 Ventilation Control. - The ventilation or recirculatory system shall provide for the conditioning and recirculation of oxygen in the pressurized suit environment. The system shall have a fan or other acceptable means of force circulating the suit atmosphere through the necessary purification, contamination, humidity and temperature control systems. In the unpressurized condition with the faceplate open or the gloves off, ventilation shall be provided to ensure the astronaut's comfort by cooling, humidity, contamination and purification control from the LEM ECS. The ventilation circuit pressure drop from the suit inlet through the suit to the suit outlet, including the male and female portions of the multiple gas connectors, shall not exceed 4.7 inches of water for a flow of 12 cubic feet per minute (cfm) of oxygen at 3.5 psia and 55°F. The pressure drop shall not be affected by more than 0.3 inches of mercury (Hg) by the crewman changing positions for the above conditions. See Figure 8 for suit flow versus Δ P characteristics. The circulating fluid shall be used to transmit heat, moisture, and undesireable gases and solids to appropriate system components. The ventilation flow shall provide oxygen circulation to the body extremities, especially to pronounced perspiration exudation areas. The ventilation system shall meet the contaminant limits of Table VI. The flow distribution to the helmet shall be sufficient to maintain the safe level of CO_2 partial

3.2.4.1.5 (Continued)

pressure of Figure 2 in the helmet, when the suit is supplied with 8 cfm at 5 psia and 60°F, with a suit inlet CO_2 partial pressure of 7.0 mm of Hg.

3.2.4.1.6 Temperature Control. - The temperature control shall maintain an internal temperature range within the helmet from 66° to 70°F when the suit is pressurized. The remainder of the suit shall not exceed an internal temperature range from 45° to 85°F. The suit shall be supplied with a flow rate of 15 cfm measured at 3.5 psia and 70°F.

3.2.4.1.7 Recirculatory System. - See paragraph 3.2.4.1.5.

3.2.4.1.8 Electrical Power. - Electrical power shall be supplied by a rechargeable battery capable of being fully charged from the LEM electrical power source. The LEM electrical power supply shall be in accordance with paragraph 3.5.1.1. The battery shall supply the power, within appropriate margins, to operate all of the required equipment, including the removable helmet light, within any minimum 4 hour phase of the mission profile. The battery shall not be in parallel with LEM power. For hardwire operation, the available power shall be LEM power as defined in paragraph 3.5.1.1. Maximum current in any biomedical lead shall not exceed 25 milliamps.

3.2.4.1.9 Voice Communication (Duplex). - Voice communication in normal operation shall be a subsystem of the duplex communication system, and includes the telemetry. The duplex subsystem shall provide for simultaneous two-way conversation between the crewman in the SSA on the lunar surface and the LEM, between two extra-vehicular crewmen in SSA, or between the crewman in the SSA on the lunar surface and the CSM transmitter and receiver using the LEM as a relay. The duplex communication system shall be compatible with the LEM equipment and approved by MSC. The communication system microphones

3.2.4.1.9 (Continued)

and earphones shall be located in the PGA helmet (See paragraph 3.2.2.1). The antenna shall not interfere with egress and ingress through the LEM hatches.

3.2.4.1.10 Telemetry Transmission (Duplex). - Telemetry transmission shall be capable in the duplex mode of operation. The telemetry subsystem shall transmit environmental and biomedical parameters to Deep Space Instrumentation Facilities (DSIF) using LEM as a relay link (See paragraphs 3.2.5.2 and 3.2.6.2). The telemetry subsystem shall be capable of transmitting at all times, in the duplex mode, while the crewman is outside the LEM, or through a hardwire input while the LEM is pressurized or decompressed. Transmission shall be at the discretion of the individual crewman. In the case of more than one crewman operating in a pressurized SSA, selection of telemetry data for transmission shall be by mutual agreement between the crewmen involved.

3.2.4.1.10.1 Calibration. - A means for calibrating the duplex system shall be provided. An electrical connector can be used in the communications and telemetry system of the backpack.

3.2.4.2 Emergency Oxygen Supply Unit. - The unit shall be capable of being worn with or without the backpack. The unit may be connected to the backpack if they are worn together. The unit shall be fastened to the torso and limb suit in a positive, attachable or detachable manner. The emergency oxygen supply unit shall contain elements of the following subsystems:

(a) Emergency pressurization control

(b) Emergency oxygen supply

3.2.5 Integrated Biomedical and Environmental Sensors. -

3.2.5.1 Biomedical Sensors. - Biomedical sensors shall provide physiological data for telemetry on the following:

(a) Respiration and Cardiac Impulses - Respiration and cardiac impulses shall be recorded using a Government furnished impedance pneumograph which has the following known characteristics:

(1) Low torque potentiometer

(2) Potentiometer resistance of 5000 ohms with an input voltage between 25 to 31.5 V DC, and a maximum output capability between 0.0 to 5.0 V DC at a maximum of 50 milliwatts (Reference paragraph 3.5.1.1). It shall be limited to a short circuit current of 50 ma and a maximum frequency response of 30 cps.

(b) Body Temperature - The temperature sensor shall be a high lev el thermistor or silicon patch, located in the chest area. The frequency response shall be at least two cycles per second to cover the normal skin temperature range with an accuracy of $\pm$ 0.1 percent. The signal conditioning circuitry shall provide for the following:

(1) A linear output (since the thermistor is a logarithmic sensor).

(2) Interchangeability of sensors to within $\pm$ 0.2°F.

(3) A balance control to allow zero adjustment, and an output level control.

(4) A potentiometer resistance of 5000 ohms with an input voltage between 25 to 31.5 V DC and a maximum output capacity between 0.0 to 5.0 V DC at a maximum of 50 milliwatts.

(5) A short circuit limit of 5 ma.

3.2.5.2 <u>Environmental Sensors.</u> - Environmental sensors shall be provided to permit the crewman to monitor his own status, and permit the crewman's status to be monitored by telemetry. The abbreviations (B) for both self-monitored and telemetered, (SM) for self-monitored, and (T) for telemetered, indicate how each of the following conditions shall be monitored:

(a) Suit pressure in psia (B)

(b) Quantity of oxygen remaining in the Portable Life Support System (PLSS) storage tank (B)

(c) Elapsed time (SM)

(d) Cumulative radiation dose (SM)

(e) Audible Warnings:

(1) Low suit pressure audible warning (SM)

(2) High oxygen primary flow audible warning (SM)

(f) Suit inlet temperature (T)

(g) Space Suit Assembly battery voltage (T)

(h) A spare channel for telemetry

3.2.5.2.1 <u>Suit Pressure.</u> - The suit pressure gage shall have an electrical output between 0.0 to 5.0 V DC over the range of 2.5 to 5.8 psid, with mechanical stops, and shall allow for pressures from 0.0 to 15 psid, without damage, or calibration error. The scale shall have a color code conforming with LED-480-4 to show a safety zone from 3.4 to 3.8 psid. The operating range accuracy shall not be less than $\pm$ 2 percent of the full scale.

3.2.5.2.2 Oxygen Quantity. - The quantity of oxygen remaining in the primary PLSS storage tank shall be measured by a temperature compensated pressure transducer and gage, operating between 0.0 and 860 psia, ± 5 percent maximum error.

3.2.5.2.3 Elapsed Time. - A means shall be provided to measure elapsed periods of time. The necessary adjustment for commencement of an elapsed period shall not be cumbersome or intricate which will prevent quick and accurate adjustments by the crewman in a pressurized SSA. The instrument face or dial shall clearly indicate the elapsed time in hours and minutes. Provisions for observing the passage of seconds, as a sweep hand, shall be made. Provisions for mission transportation as part of the SSA shall be incorporated in such a manner that the instrument is protected against accidental shock and accidental snaring on projecting encumberances in or out of the LEM. The above provisions shall not intefere with the support and restraint system for the crewman in the LEM.

3.2.5.2.4 Cumulative Radiation Dose. - The cumulative radiation dosage shall be recorded by a Government furnished radiation dosimeter. The radiation exposure limits are tabulated in Table II for single emergency exposure and for cumulative exposure based upon major components of the body.

3.2.5.2.5 Audible Warning. - Audible warning subsystems for self-monitoring shall function with the following limits:

(a) The low suit pressure audible warning subsystem shall be activated when the suit pressure drops to 3.0 psia. The subsystem shall automatically reset when the suit pressure rises above 3.5 psia.

(b) The high oxygen primary flow audible warning subsystem shall be activated when the oxygen rate exceeds the maximum normal usage based upon satisfying peak metabolic needs and maximum normal leakage rate.

3.2.5.2.6 Suit Inlet Temperature. - The suit inlet temperature sensor shall be incorporated in the suit pressure subsystem of paragraph 3.2.5.2.1.

3.2.5.2.7 Space Suit Assembly Battery Voltage. - The SSA battery voltage output, through the attenuator and current limiting circuit, shall equal 5 V DC for an open circuit battery voltage, with an accuracy of ± 2 percent.

3.2.5.3 Sensor Location. - Sensors and monitoring devices shall be arranged without interfering with the restraint system, the PLSS transportation system, and the crewman's movements entering or leaving the LEM.

3.2.6 Integrated Communication and Telemetry Equipment. -

3.2.6.1 Communication. - Primary communications shall provide a two-way simultaneous voice communication between an extra-vehicular SSA, and another extra-vehicular SSA, the CSM or the LEM, using the LEM as a relay (Paragraph 3.2.4.1.9). This transmission shall not interfere with the signal transmission from the physiological and environmental sensors in paragraph 3.2.6.2. A hardwire plug-in connection shall be provided for intra-vehicular operation in the LEM, or as required in the CSM.

3.2.6.1.1 Emergency Communication. - A second independent voice communication system (simplex) shall be available with its own power supply and circuitry. Operation of the simplex communication system shall be governed by a manually operated switch. Telemetry data shall not be considered in this backup system. The system shall be capable of voice communication between two extra-vehicular SSA.

3.2.6.2 Telemetry. - Physiological and environmental signal transmission shall be provided between the extra-vehicular SSA and Deep Space Instrumentation Facility (DSIF), using LEM as a relay station. Intra-vehicular transmission shall be provided through a hardwire to the LEM for relay to the DSIF (Paragraph 3.2.4.1.10).

3.2.6.2.1 Emergency Transmission. - Data from biomedical sensors need not be transmitted during emergency operation (See paragraph 3.2.6.1.1).

3.2.7 SSA Waste Management. - The SSA Waste Management shall not allow undesireable contaminants to enter the LEM atmosphere.

3.2.7.1 Urine Removal. - Provisions shall be incorporated in the PGA to collect, store and remove urine. The urine storage capacity shall be a minimum of 1.3 liters. The removal of urine shall be possible when the suit is pressurized or unpressurized. The facilities for collection, storage and removal of urine shall not reduce the mobility of the crewman below minimum mobility requirements, or interfere with crewman's restraint provisions.

3.2.7.2 Defecation Removal. - Provisions shall be incorporated in the PGA to collect, store and, or, remove fecal matter. The storage capacity of feces shall be a minimum of 500 cc for a 96 hour mission. The facilities for collection, storage and, or, removal of feces shall not reduce the mobility of the crewman below the minimum mobility requirements, or interfere with the crewman's restraint provisions.

3.2.7.3 Flatus Contamination. - Provisions shall be incorporated in the SSA to collect, store, and recondition flatus. A filtration subsystem shall process the flatus which will remove objectionable odors, explosive, noxious, nauseous or toxic gases and solid particles before reintroducing the remaining gases into the recirculatory system. Flatus collection shall be integrated with fecal collection. The facilities for collection, storage and reconditioning of flatus shall not reduce the mobility of the crewman below the minimum mobility requirements, or interfere with the crewman's restraint provisions.

3.2.8 SSA Vomitus Management. - Provisions shall be incorporated to either collect, remove and store, or to distribute the PGA vomitus material to preclude possible interference with the operation of the life support systems. The management capacity shall be one pint minimum. Vomitus management shall be possible when the suit is pressurized or unpressurized. The facilities for collection, storage and removal shall not reduce the visibility provisions, nor restrict the restraint provisions for support of the crewman in the vehicle.

3.3 Material Selection and Environmental Conditions. -

3.3.1 Material Selection. -

3.3.1.1 Materials and Processes. - In the selection of materials and processes, fulfillment of major design requirements shall be the prime consideration. Materials and processes selected shall be subject to NASA-MSC approval, with Grumman compatability assent.

(a) Processing equipment and certification of processing personnel shall be subject to NASA-MSC approval.

(b) When substitutions, temporary or otherwise, are made, drawings shall note the applicable government specification of the alternate material when applying for NASA-MSC approval and Grumman assent.

3.3.1.2 Material Degradation. - Materials selected shall not, as a result of exposure to its service environment storage or usage, evolve degradation products of such a nature or quantity that the operation of the LEM, LEM components, or the part itself and its system are impaired. Exposure of a material to its service environment (paragraph 3.3.2) or usage shall not produce toxic, nauseous, or harmful degradation

3.3.1.2 (Continued)

products. The SSA material shall not be combustible below 350°F in a 5 psi pure oxygen atmosphere, nor contribute to a potential fire or explosion hazard in the crew compartment. In the event of combustion, the SSA material shall be self-extinguishable upon removal of the source of heat initiating the combustion in the environments listed in Table I.

3.3.1.2 Dissimilar Materials. - Materials shall not be used that will produce detrimental interaction injurious to the crew or leading to deterioration of physical characteristics of the materials by contact, proximity or gaseous emission, with other materials in the SSA or materials in the LEM under the environmental conditions of Table I.

3.3.2 Environmental Conditions. - The SSA shall be capable of being worn or stored under the following environmental conditions without detrimental degradation.

3.3.2.1 Non-Pressurized Intra-Vehicular Conditions. - The LEM cabin atmosphere before and during earth launch and until transposition shall be either ambient pressure, temperature and composition, or, pure oxygen with a pressure differential range from zero to 5.8 psia maximum with ambient and approximately ambient temperature.

During the translunar injection phase, penetration of the Van Allen Radiation Belts will occur (See Figure 1). See Table I for other detailed environmental characteristics. Other unpressurized occurances of the LEM cabin will either be intentional, or accidental. These occurances will expose the LEM cabin to free-space and lunar surface environments characterized in Table I.

3.3.2.2 Pressurized Intra-Vehicular Conditions. - Pressurized intra-vehicular conditions after transposition shall provide a cabin atmosphere of pure oxygen plus water vapor and residual carbon dioxide pressurized at nominally 5 psia (maximum of 5.8 psia). The carbon dioxide partial pressure limits are defined by Figure 2. Additional environmental data is available in Table I.

3.3.2.3 Extra-Vehicular Conditions. - Extra-vehicular environments that would be encountered by extra-vehicular excursions from the LEM are those of free-space and the lunar surface. Figures 3, 4 and 5 represent the electromagnetic spectrum of solar radiation. Background radiation from celestial sources shall be considered 10^{-4} ergs/cm^{2}/sec/A^{o} in the interval of 1230 to 1350 angstroms (A^{o}). The Earth's albedo shall be considered at 35 percent. Table II establishes the nominal biological dose limits with regard to exposure and components of the body. Other characteristics of free-space and lunar surface environments are in Table I.

3.4 Operational Duties. -

3.4.1 Nonpressurized Intra-Vehicular Duties. - The crewman wearing a nonpressurized SSA shall be able to perform all the tasks required in the operation of the LEM as established by the mission requirements. The degree of mobility shall be comparable to the Navy Mark IV pressure suit (paragraph 3.1.1.1).

3.4.2 Pressurized Intra-Vehicular Duties. - The crewman wearing a pressurized SSA shall be able to perform all the necessary tasks required in the operation of the LEM as established by the mission requirements. These include a minimum of the following:

(a) Operation of guidance and navigation equipment (G&N) including optical and radar equipment.

(b) Operation of the stabilization and control (S&C) controllers.

3.4.2 (Continued)

(c) Operation of the communications equipment.

(d) Operate switches, turn dials and read displays.

(e) Recharge, change or otherwise maintain essential equipment, such as electronic components, ECS equipment and the PLSS.

(f) Operate the hatches.

(g) Performing certain emergency procedures under adverse conditions.

3.4.3 Pressurized Extra-Vehicular Duties. - Two general classes of pressurized extra-vehicular excursions are free-space trips and lunar surface expeditions. The free-space trips may vary from the normal mission, while the latter may be either.

3.4.3.1 Free-Space Trips. - Free-space trips shall be possible for emergency inspection repair, or free-space transfer. During these trips, it shall be possible to handle the tools and equipment required to perform the task.

3.4.3.2 Lunar-Surface Expeditions. - Some lunar surface expeditions are scheduled as normal procedure and are intended for performing certain prescribed tasks. A few of these will be assembling and using scientific equipment, exploring the lunar surface, accumulating soil samples and possibly some preparatory tasks, before lunar ascent. Unscheduled activity could be a rescue mission or repair work to the ascent vehicle.

3.5 Detail Requirements. -

3.5.1 Electrical Design. - Shall have elementary requirements set forth herein.

3.5.1.1 Electrical Power. - Electrical power will be supplied by the LEM-EPS for hardwire use in intra-vehicular operation. The SSA shall be capable of operating with the electrical power with the following characteristics:

(a) The operating voltage shall be 28 V DC nominal with steady state limits from 25 to 31.5 V DC.

(b) Low line limits of electrical power shall be from 20 to 32 V DC for periods not to exceed 5.0 seconds.

(c) Positive transient voltage limit shall be 50 volts superimposed upon steady state level for 10 microseconds at 10 pps repetition rate for a period of 5 minutes.

(d) Negative transient voltage limit shall be 100 volts superimposed upon steady state level for 10 microseconds at 10 pps repetition rate for a period of 5 minutes.

(e) Ripple shall be in accordance with Standard MIL-STD-704.

(f) The negative power line shall serve as ground.

(g) All electrical elements shall be electrically isolated from their housing with ground path provided only through the ground system in accordance with step (f) above.

(h) Electrical or electronically operated equipment shall maintain the required performance characteristics using the prime power as specified in steps (a) and (b) above.

3.5.1.2 Electromagnetic Interference. - No component, subassembly, assembly, subsystem, system or the SSA shall cause electromagnetic interference beyond the limits specified in Specification LSP-530-001-1.

3.5.1.3 Electrical Component Design. - All electrical, or electrically operated, components shall be designed for the service and environmental conditions of this specification (See paragraph 3.3.2).

3.5.1.3.1 Operating Voltages. - Components shall be designed for normal and emergency operating voltages as specified in paragraph 3.5.1.1 (a) and (b).

3.5.1.3.2 Motors. - Motors using mechanical commutation or slip rings shall not be used.

3.5.1.3.3 Dielectric Strength. - Electrical, or electrically operated components, excluding instrumentation, shall withstand, without electrical breakdown, a dielectric voltage of 1500 V DC, 60 cps, at sea level in accordance with Standard MIL-STD-202B, Method 301.

3.5.1.3.4 Insulation Resistance. - Insulation resistance of electrical or electronically operated components, excluding instrumentation, shall be a minimum of 5000 megohms at room temperature in accordance with Standard MIL-STD-202B, Method 302.

3.5.1.3.5 Ignition Proof. - Electrical components or electrically operating components, operating or not operating shall not be capable of igniting any exposed mixture existing in the SSA, the LEM or other environment that may be encountered on the LEM mission, and shall not contribute to the generation of toxic, noxious, nauseous, flammable, explosive or moisture mixtures without providing reliable means for containment, control and harmless dispersion of these mixtures.

3.5.1.3.6 Corona. - Sparkover, surface discharge, breakdown or other forms of electrical discharge corona shall not occur from any electrical potential under any environmental circumstance listed in Table I. Corona glow shall not produce ozone or any other toxic gases in excess of the LEM-ECS purification capability.

3.5.1.3.7 Switches. -

(a) All switches shall be hermetically sealed.

(b) All electrical disconnects shall be controlled by hermetically sealed switches and, in addition, an interlock shall provide positive means of preventing physical disconnect before electrical disconnect.

3.5.1.4 Electrical Bonding. - Shall be in accordance with Specification LSP-390-001.

3.5.1.5 Fail-Safe Requirements. - See paragraph 3.5.12.

3.5.1.6 Wire. - The electrical wires shall not cause degradation of materials, affect the crewman, or produce malfunction of the SSA through chemical, electrical, or mechanical means.

3.5.1.7 Wiring Identification. - Wiring shall be identified in accordance with Standard MIL-STD-681.

3.5.2 Electronic Design. - The electronic design shall provide for a communications system and a telemetry system set forth herein.

3.5.2.1 Electronic Power. - See paragraph 3.5.1.1.

3.5.2.2 Electronic System. - The electronic system shall be composed of a duplex (See paragraphs 3.2.6.1, 3.2.4.1.9 and 3.2.4.1.10) and a simplex (paragraph 3.2.6.1) subsystem. The system shall incorporate the controls and displays necessary for the proper operation of the SSA.

3.5.2.2.1 Controls and Displays. - The communications system controls and displays shall include a minimum of:

(a) Switch to change from duplex to simplex mode.

(b) Switch to turn the telemetry on and off.

3.5.2.2.1 (Continued)

(c) Switch to turn power on and off for duplex and simplex.

(d) Switch to change antenna to duplex or simplex mode which may be ganged to switch in step (a).

(e) Switch to change antenna from simplex receive to simplex transmit.

3.5.3 Instrumentation Design. - Transducers furnished under the requirements of this specification shall ensure maximum reliability, personnel safety, have minimum weight and power and cost, and maximum operating utility. The materials used in the design and construction shall conform with paragraph 3.1, and shall be of high, uniform quality, capable of withstanding the electrical and environmental conditions specified herein. Units or parts shall be bonded in accordance with Specification LSP-390-001.

3.5.3.1 Dielectric Strength. - Electrical or electrically operated components shall withstand, without electrical breakdown, a dielectric voltage of 350 V DC, 60 cps at sea level, in accordance with Standard MIL-STD-202B, Method 301.

3.5.3.2 Insulation Resistance. - The unit insulation leakage resistance from any pin to case shall be more than 100 megohms at 100 V DC according to Standard MIL-STD-202B, Method 302.

3.5.4 Thermal Design. -

(a) LEM Intra-Vehicular Operation - When the thermal garment is not worn, the PGA outer layer shall be designed to minimize radiative heat transfer to the surroundings in the cabin. The total convective heat transfer to the cabin shall be approximately 125 BTU per hour when the cabin atmospheric temperature is 75°F and the heat capacity of the suit flow is 111 BTU per hour.

3.5.4 (Continued)

(b) LEM Extra-Vehicular Operation - The thermal garment shall provide sufficient insulation to meet the requirements of lunar and free-space environment as accepted by MSC-CSD. An estimate of lunar and free-space environments and the characteristics of insulating materials may be found in Chance Vought Report 00.235 (Contract Number NAS 9-1163) and LED-520-2.

3.5.5 Structural Integrity Design. - The structural integrity design shall conform, but not be limited to the minimum requirements of the pressure, vibration, shock, acoustical, radiation and meteoroid levels specified herein.

3.5.5.1 Pressure. - The nominal operating pressure of the inflated suit shall be 3.5 psia (paragraph 3.2.4.1.4) and the exterior environmental characteristics are detailed in Table I. The SSA shall be capable of maintaining the pressure level for a minimum of 5 minutes, with normal ventilation and respiration efficiency, if the pressure garment is pierced by an object producing a minimum opening the size of 0.09 inches in diameter. The suit shall be capable of withstanding an internal static overload pressure of 10 psig for a period of 5 minutes.

3.5.1.1 Leakage. - The permissable leakage rate for the SSA shall not exceed 200 cc per minute when inflated to 3.5 psia in a lunar surface or free-space environment.

3.5.5.2 Vibration. - The equipment in the SSA shall be designed to eliminate inducing objectional vibration levels to the crew members. Self induced vibration levels of SSA transmitted to the crew members shall not exceed:

(a) 0.04g from 5 to 50 cps

3.5.5.2 (Continued)

(b) 0.0003 inch double amplitude (DA) from 50 to 100 cps

(c) 0.15g from 100 to 2000 cps

3.5.5.2.1 Vibration Environment. - The SSA shall be capable of functioning at design levels when operating under the conditions described in Table I.

3.5.5.3 Acoustical Noise. - Acoustical noise levels generated by the SSA shall not exceed the noise nonstressed level of 70 db overall and 45 db in the 600 to 4800 cps range when measured at the ear level of the crew members in the LEM lunar surface or free-space environments. Minimum noise attenuation of the helmet and sound attenuation cups shall be as specified in paragraph 3.2.2.1 (f).

3.5.5.4 Shock. - The SSA shall be capable of withstanding the loads imposed by Table I and remain a functional item. The shock loads of lunar landing and rendezvous docking shall be considered as being applied during the operational use of the SSA, and there shall be no reduction in capability of the item through the shock period or thereafter.

3.5.5.5 Radiation. - The radiation environment shall be in accordance with Table I. The minimum radiation protection afforded by the SSA shall be:

Radiation Particles	Energy (MEV) Attenuated
Alpha	60.0
Proton	20.0
Electron	1.0

3.5.5.6 Meteoroids. - Meteoroid environment for the Apollo mission consists of sporadic and shower meteoroids defined as follows (Reference: Ltr. SLE-13-63-427, J. L. Decker):

(a) Sporadic Meteoroids:

$$\mathrm{Log}_{10} N = -1.34 \log_{10} M - 10.423$$

When: Density = 0.5 grams/cc, all sizes

Velocity = 30 km/sec., all sizes

Where: N = number of impacts per square foot per day

M = mass in grams

(b) Shower Meteoroids:

$$\mathrm{Log}_{10} N = -1.34 \log_{10} M - 10.423 + \log_{10} F$$

When: Density = 0.5 gms/cc, all sizes

Velocity = as noted in Table IV

Direction = as noted in Table IV

Where: F = ratio of shower to sporadic rates given in Figure 12

3.5.5.6.1 Penetration Mechanics. - The Summers penetration equation shall be used for sporadic and shower meteoroid penetration applications for a finite thickness and double wall structures:

$$\sum t_1 = 4.24 K \rho_m^{1/3} M_p^{1/3} \left(\frac{Vm}{C_t \rho_t}\right)^{2/3}$$

3.5.5.6.1 (Continued)

Where: t_1 = individual finite-sheet thickness in centimeters.

K = multi-sheet efficiency factor (See Table V).

M_p = penetrating meteoroid mass in grams.

V_m = meteoroid impact velocity in kilometers per second.

C_t = target material sonic velocity in kilometers per second.

ρ_m = meteoroid density in grams per cubic centimeters.

ρ_t = target material density in grams per cubic centimeters.

3.5.6 Visibility. - See paragraph 3.2.2.1 (e).

3.5.7 Restraint Provisions. - The SSA shall be designed to use a conventional type shoulder harness and lap belt, or a parachute type harness as a means of restraining the crewman in his station. The possibility exists that an arm and head restraint may be needed. The final configuration of the crewman's station and the restraint system shall determine the type of restraint and how it will be imposed upon the man. The restraint system shall have self-don and self-doff capabilities when the crewman is in a pressurized suit.

3.5.8 Don-Doff Considerations. - The CWG and the PGA will be worn throughout the LEM excursion phase of the mission. Under normal conditions, self-donning and self-doffing of the thermal garments and the PLSS presents a problem in a highly restricted area. The space allotment for these activities are severely restricted and must be considered in the design of the SSA (See Figure 10b).

3.5.9 Weight and Apportionment. - The total weight of the Space Suit Assembly shall not exceed 60 pounds, including expendables. The center of gravity (CG) of the SSA shall roughly approximate the CG of the wearer. The CG of the crewman wearing the complete SSA shall not vary by more than 3 inches vertically and 2 inches horizontally from the CG of the crewman nude.

3.5.10 Reliability. - Reliability requirements shall not permit a failure in the SSA to propagate sequentially and adversely affect any LEM component or system. The probability of a successful 4 hour mission of the SSA in free-space or on the lunar surface, shall be 0.999995.

3.5.10.1 The probability than an SSA is in a full operable condition before its use as the primary means of life support and, or its use in an emergency condition, shall have a reliability goal of 0.999999. This goal shall include the time from preflight checkout through the time interval when the suit is used as the primary means of life support in a space environment.

3.5.11 Fail-Safe Requirements. - All components, subassemblies, assemblies, subsystems and systems shall be designed so that a failure shall not propagate sequentially. The design shall "fail-safe".

3.5.12 Operating Life. - The SSA shall be designed to perform satisfactorily without major overhaul after being donned, worn, operated and removed as many times as necessary for preflight checkout and mission completion, including a margin of safety as specified in Table IA. All operating and checkout procedures shall be compatible with LEM-ECS procedures.

3.5.13 Physiological Requirements. - The SSA shall maintain the crewman within the physiological tolerances specified in Exhibit B, Technical Approach, contract NAS 9-1100, Lunar Excursion Module, Project Apollo. Grumman shall supply a metabolic profile for operation in the LEM which will provide peak load, mean load, total BTU output, thermal transfer rate and latent and, or sensible breakdown of the aforementioned.

3.5.14 Sterilization Requirements. - None.

3.5.15 Static Discharge. - Provisions shall be made to prevent the accumulation of static potential between components of the SSA, and between the SSA and the LEM. The potentials shall not reach the magnitude that will produce a spark discharge or disrupt the electronic equipment in the SSA or the LEM.

3.6 Accessories. -

3.6.1 Umbilicals. - Umbilical assemblies for gases and electrical or electronic power shall be provided, in some cases, as accessories to the SSA. Umbilicals are required between the PLSS and the PGA, and the SSA and the LEM or another SSA. The umbilical between components of the SSA shall be considered as accessories to the SSA. Umbilicals between the SSA and the LEM-SSA shall be supplied as GFE in-flight equipment from the CM. The in-flight supplied umbilicals shall have identical connector fittings at both ends to mate with the connector fittings on the LEM and, or SSA. The basic connector shall be SSA equipment. At least, one of two gas umbilicals to be supplied in flight shall have incorporated, a low pressure drop, on-off valve, permitting its use in the "Buddy System" operation. The routing of the umbilicals from the SSA to the LEM shall pass between the legs of the crewman just below the crotch to minimize entanglement and the length of the umbilicals. The umbilicals shall not interfere with the support and restraint subsystem of the crewman in the LEM.

3.6.1.1 "Buddy System". - The SSA shall have the capability of accomodating the "Buddy System" of operation without additional adapters or fittings. The "Buddy System" of operation shall permit the operation of two pressurized PGAs from a single PLSS in an emergency. An in-flight CM supplied gas umbilical with an on-off valve shall be available (paragraph 3.6.1) for instituting the "Buddy System" operation. The umbilical with valve shall permit an environmental loop to operate two PGAs from a single PLSS, in cases of malfunction or exhaustion of a PLSS. This type of operation will burden the remaining PLSS and any extended operation in this mode will materially reduce the operating time capability of that PLSS. During this operation, the rate of consumption of the expendables shall not exceed twice that of the normal operational rate. This mode shall not have any effect upon the operational characteristics of the SSA when the "Buddy System" is not used, or has been terminated beyond the above mentioned reduction in operational time.

3.6.1.2 Umbilical Connectors. - Provisions shall be provided to receive LEM umbilical assemblies for gases and electrical or electronic power.

4 QUALITY ASSURANCE PROVISIONS

4.1 Scope. - This section of the specification establishes the general test requirements and test plans to be followed at Grumman during the SSA performance and interface program. It is anticipated that more definitive requirements will be incorporated in this section of the specification when the detailed test procedures have been established by Grumman. The test program shall consist of detail tests in the following categories:

(a) Delivered Item Acceptance Tests - The following tests are required by NASA Quality Publication NPC 200-2 (Reference paragraph 5.3 of this specification).

(1) General visual inspection

(2) Assembly tests

(3) Pressure tests

(4) Continuity tests

(5) Functional tests

(6) Weighing of major SSA components

(b) Performance Interface Tests:

(1) Mobility tests

(2) Visibility tests

(3) Comfort tests

(4) System functional tests

(5) Stowage and replenishment tests

4.1. (Continued)

(c) Miscellaneous Tests:

(1) Material combustion tests in a pure oxygen atmosphere in reference to LED 520-3.

4.1.1 Development Tests. - Development tests shall be those performed by the Associate Contractor developing the SSA and shall include design feasibility and detail design verification tests. The scope and magnitude of these tests shall be under the direction of MSC with cognizance of Grumman. Design verification tests involving interface with LEM, LEM components or LEM environment shall be performed or directed by Grumman with cognizance of MSC. Tests-to-failure shall be employed to establish failure modes, frequencies and weak link characteristics for verification and comparison to analyses and to determine the adequacy of the design margins.

4.1.2 Witnessing of Tests. - MSC, through Resident Apollo Space Project Office (RASPO), shall be advised one week in advance when Performance Interface Tests will be performed so a representative of MSC may be present to witness the tests. Waiver of this requirement or delegation of alternate authority shall be at MSC's descretion.

4.1.3 Criteria for Rejection. - Criteria for rejection shall be stated in the test procedure.

4.2 Test Facilities. -

4.2.1 General. - Private, commercial, government or Grumman owned test facilities may be used subject to MSC approval.

4.2.2 Environmental Requirements. - The environmental requirements of individual tests shall be described in the test plan for that test, including calibration and tolerance limits to be maintained.

4.2.3 Special Equipment and Adapters. - Any special equipment or adapters shall be explained in detail or common usage terminology in the test plan for that test, including calibration and tolerance limits to be maintained.

4.3 Test Procedures. -

4.3.1 General. - The testing procedure of individual tests shall be defined in the test plan of that test.

4.3.2 Calibration. - Calibration procedure for test equipment shall be established in the test plan of the individual tests.

4.3.3 Safety and Operational Environment. - The procedures shall incorporate safety precautions for the test equipment, the equipment being tested and the people performing the tests. The operational environment shall be simulated to the extent required by the operational phase of the equipment being tested.

4.4 Tests. -

4.4.1 Delivered Item Acceptance Tests. - (To be specified. See paragraph 4.1 (a).)

4.4.2 Performance Interface Tests. - (To be specified. See paragraph 4.1 (b) and 3.5.4.)

4.4.3 Miscellaneous Tests. - (To be specified. See paragraph 4.1 (c).)

5 PREPARATION FOR DELIVERY

5.1 Maintenance. - A detail, subassembly, assembly, subsystem and system parts breakdown and engineering drawings shall be provided with the proper nomenclature, part identification number and quantities per assembly and per SSA.

5.1.1 Manuals. - Manuals shall be provided to explain the operation of the SSA, detail the maintenance and maintenance procedure required to keep the SSA at maximum operating condition and explain and detail means of repair to damaged or weakened components.

5.1.2 Follow-Up. - Grumman shall be informed of modifications, changes and alterations to the SSA. Periodic bulletins (to be determined) shall notify Grumman of the types and forms of inspection and operational rejections of similar units issued to other agencies.

5.1.3 Special Tools and Equipment. - Special tools or equipment shall be provided for servicing, maintaining, operating, handling or stowing the SSA.

5.2 Spare Parts. - Spare parts shall be considered as expendable parts and parts that must be replaced because they are defective or otherwise unusable.

5.2.1 Expendable Parts. - Expendable parts shall be fully identified as to substance, including finish, shape, condition, quantity and manner of installing. The quantity of expendable parts will be determined by Grumman with MSC approval.

5.2.2 Replaceable Parts. - Replaceable parts shall be identified per paragraph 5.

5.3 Transfer Documents. - Each SSA received shall be accompanied by a certification of qualification and acceptance tests, including weighing of shipped major components, performed by the manufacturer in order to conform to the requirements of NASA Quality Publication NPC 200-2.

5.4 Delivery, Handling and Stowage. - (To be specified.)

6 NOTES

6.1 Abbreviations. -

A°	Angstrom (10^{-8} centimeter)
BTU/ft^2 hour	British Thermal Units per square foot hour
CG	Center of gravity
cfm	Cubic feet per minute
clo	$0.88 \frac{^\circ F}{BTU/ft^2\ hr} = 0.18 \frac{^\circ C}{Kcal/m^2\ hr}$
cm	Centimeter
CM	Command Module
cps	Cycles per second
CSD	Crew Systems Division of MSC
CSM	Command Service Module
CWG	Constant Wear Garment
DA	Double Amplitude
db	Decibel re: 0.0002 dynes per square centimeter
DSIF	Deep Space Instrumentation Facilities
ECS	Environmental Control System
EPS	Electrical Power Subsystem
FPM	Feet per minute
g	Gravitational Acceleration (32.2 ft/sec^2)
g^2/cps	Spectral Density (mean - square acceleration density)
GAEC	Grumman Aircraft Engineering Corporation, Bethpage, Long Island, New York, 11714
GFE	Government Furnished Equipment
G & N	Guidance and Navigation
Hg	Mercury
LEM	Lunar Excursion Module

6.1 (Continued)

ma	milliamperes
MEV.	Million electron volts
mph	miles per hour
ms	millisecond
MSC	Manned Spacecraft Center, National Aeronautical and Space Administration
ns	non-stressed
PGA	Pressure Garment Assembly
PLSS	Portable Life Support
PPM	Parts per million
pps	Pulses per second
psia	Pounds per square inch absolute
psid	Pounds per square inch differential
q	Dynamic pressure
R/sec (rad/sec^2)	radians per second per second
RASPO	Resident Apollo Spacecraft Project Office
rad	An absorbed radiation unit equivalent to 100 ergs per gram
RBE	Relative biological effectiveness
rem	A measure of the radiation tolerance of humans
RH	Relative humidity
S & C	Stabilization and Control
S-IC	Saturn First Stage
S-IIC	Saturn Second Stage
SSA	Space Suit Assembly
vib	Vibration
P	Pressure drop across the Space Suit Assembly pounds per square inch
$\leq$	Less than or equal to
#/hr	pounds per hour
$\#/ft^3$	pounds per cubic foot

6.2 Definitions. -

(a) Approval - Approval shall be construed to mean positive action by letter, TWX, telephone memorandum from the approving agency or other official document, and by default if no action is taken within thirty (30) days after request for approval has officially been issued.

(b) Assent - Assent shall be construed to mean acceptance of the proposed intent as compatible with existing design and technical development, and shall be conveyed by either positive or default procedure outlined in 6.2.1.

(c) Component - A component is a part, assembly or combination of parts, subassembly, subsystem or system mounted or joined together to perform a design function.

(d) Hardwire - A physical connection between nominally independent units for limited or short term operation.

(e) Interface - An interface is the junction point or points within or between systems or subsystems where matching or accomodation must be properly achieved in order to make their operation compatible with the successful operation of all other functional entities in the space vehicle, modules or its ground support equipment.

(f) Performance and Interface Specification - A performance and interface specification is a specification about GFE which defines the over-all performance and interface requirements in terms of configuration, performance, reliability and environmental conditions.

(g) Reliability - Reliability is the probability that a system, subsystem, component or part will perform its required functions under defined conditions at a designated time and for a specified operating period.

6.2 (Continued)

(h) Subsystem - A major functional part of a system, usually consisting of several components which is essential for operational completeness of the system.

(i) Unit.- An assembly or any combination of parts, subassemblies and assemblies mounted together and normally capable of independent operation in a variety of situations.

(j) Assembly - A multipart which may be dissassembled without destruction and which does not independently have any application or use of its own, but is essential for the operational completeness of of the equipment with which it is combined.

(k) Subassembly - Two or more parts which form a portion of an assembly or a unit replaceable as a whole, but having a part or parts which are individually replaceable.

(l) Part - One piece, or two or more pieces joined together which are not normally subject to disassembly without destruction of design use.

TABLE I

LEM ENVIRONMENTAL AND LOAD CONDITIONS

NOTES: (1) Factors of Safety are not included in the levels specified herein. See Table IA.

(2) All accelerations are "earth g's". Multiply by earth weight, or use 32.2 ft/sec^2 as appropriate.

(3) Vibration spectra refer to straight line plots on log-log paper.

(4) Prelaunch Packaged and Prelaunch Unpackaged classifications refer to transportation, handling and storage in the appropriate mode.

(5) See Figure 11 for directional orientation.

TABLE I (Continued)

(a) Prelaunch Packaged

Acceleration:	(ns)	2.67g vertical on 1.0g lateral applied to the package
Shock:	(ns)	Transportation, handling and storage in the package shall not produce critical design loads on the Space Suit Assembly or its components and shall not effect an increase in weight. Test in accordance with *MIL-STD-810(USAF), Method 516 Procedure III.
Vibration:	(ns)	The following vibration levels are specified during transportation, handling and storage. Vibration to be applied along three (3) mutually perpendicular axes, X, Y and Z to the package at 1/2 octave per minute.

For 100 lbs.** total weight or less

cps	g or DA
5 - 7.2	0.5 inches DA
7.2 - 26	± 1.3g
26 - 52	0.036 inches DA
52 - 500	± 5.0g

For 100 - 300 lbs total weight

Use Figure 514-8, Method 514 of MIL-STD-810 (USAF) for maximum frequency.

***Pressure:	Atmospheric pressure corresponding to sea level to 50,000 ft.
Temperature:	$-65^{o}F$ to $+160^{o}F$

- - - - - - - - - - -

(ns) These levels of environment and loads do not occur simultaneously.

* MIL-STD-810(USAF) of 14 June 1962

** Total weight refers to weight of the unit plus the weight of the package.

*** Ambient environment on outside of package.

TABLE I (Continued)

(a) (Continued)

***Humidity:	0 to 100% relative humidity including condensation.
***Rain:	In accordance with MIL-STD-810(USAF), Method 506.
***Salt Spray:	Salt Spray as encountered at a beach area (equivalent to spray of 5% salt solution in water for 50 hours).
***Sand and Dust:	As in desert and ocean/beach area (equivalent to 140 mesh silica flour with particle velocity up to 500 FPM).
Fungus:	In accordance with MIL-STD-810(USAF), Method 508.
***Ozone:	Exposure with 0.05 PPM concentration (1/2 toxic limit).
***Hazardous Gases:	Explosion proofing in accordance with MIL-STD-810(USAF), Method 511.
***Electromagnetic Interference:	In accordance with LSP-530-001.

(b) Prelaunch Unpackaged

Acceleration:	(ns)	2.67g vertical with 1.0g lateral.
Shock:	(ns)	In accordance with MIL-STD-810(USAF), Method 516, Procedure I modified. Modify shockpulse to saw tooth 15g peak 10-12 ms rise, 0-2 ms decay.
Vibration:	(ns)	Same as prelaunch packaged but to apply to the item.
Pressure:		Ambient ground level pressure (Hermetically sealed units installed in the crew compartment will be subjected to a limit pressure of 20 psi absolute during preflight checkout). (Pressure vessels-gage pressure will vary from ambient to proof gage pressure.)

TABLE I (Continued)

Temperature:	$-20^{\circ}F$ to $110^{\circ}F$ Ambient Air Temperature plus 360 BTU/ft^2hour up to 6 hr/day.
Humidity:	15% to 100% relative humidity including condensation.
Rain:	Same as packaged but no direct impingement.
Salt Fog:	In accordance with MIL-STD-810(USAF), Method 509.
Sand and Dust:	Same as Prelaunch Paclaged.
Fungus:	Same as Prelaunch Packaged.
Ozone:	Same as Prelaunch Packaged.
Hazardous Gases:	Same as Prelaunch Packaged.
Electromagnetic Interference:	Same as Prelaunch Packaged.

(c) Launch and Boost (C-5)

Acceleration:

Acceleration	X	Lateral Axis Normal to X
Earth Orbit (zero g)	0	0
Boost Cond.	+4.7g	$\pm$ .1g
Burnout Cond.	-2.6g	$\pm$ .1

Vibration: The mission environment consists of the following random spectrum applied for 17 minutes along each of three mutually perpendicular axes; X, Y and Z.

TABLE I (Cont.)

5 - 27 cps	$0.18g^2$/cps Constant
27 - 40 cps	12 db/octave roll-off
40 - 2000 cps	$0.036g^2$/cps Constant

Rigidly Mounted Equipment Weighing More Than 10 Pounds. - The vibration levels above, both random and superimposed sinusoidal, can be decreased at (see below) frequencies greater than one-half the first local vibration.

For rigidly mounted equipment 10 lbs. to less than 100 lbs. $A_2 = A_1\ (1.5-.5\ \log_{10}W)$ where:

A_1 = Required vib. level for less than 10#

W = Package weight

A_2 = Package vib. level in g's

For package weight of 100 lbs. and up

$A_2 = \frac{1}{2}A_1$

Acoustics:

Octave Band	*** Level (db) Max q
9 to 18.8	142
18.8 to 37.5	141
37.5 to 75	141
75 to 150	138
150 to 300	134
300 to 600	130
600 to 1200	123
1200 to 2400	116
2400 to 4800	110
4800 to 9600	104
overall	147

***Sound pressure level in db (re: .0002 dynes/cm^2) external to LEM.

TABLE I (Cont.)

Pressure: Atmospheric pressure at sea level to 5.8 psia (oxygen atmosphere).

Temperature: 0°F to +160°F

Humidity:

Hazardous gas: Same as pre-launch Packaged.

Electromagnetic Interference: Same as Prelaunch Packaged.

(d) Space Flight

Acceleration:

X	Lateral	Pitch
- .450g	± .110g	± .373 rad/sec^2
- .84g	± .12g	± 17.0 rad/sec^2

Vibration: The mission environment consists of the following random spectrum applied for 6 minutes along each of the three perpendicular axes; X, Y and Z.

5 - 47 cps	0.089g^2/cps Constant
47 - 65 cps	12 db/octave roll-off to
65 - 1000 cps	0.024g^2/cps Constant
1000 - 2000 cps	12 db/octave roll-off

TABLE I (Cont.)

Pressure:	5.4 to 0.1 psia (Oxygen)
Temperature:	0°F to 160°F (uncontrolled cabin) 70°F to 80°F (controlled cabin)
Humidity:	40-70% R.H. in controlled cabin (average) 40-100% R.H. in uncontrolled cabin (average)
Ozone:	To be determined.
Hazardous Gases:	Same as Prelaunch Packaged.
Electromagnetic Interference:	Same as Prelaunch Packaged.

(e) Lunar Descent (Including separation, descent, hover and touchdown)

Acceleration:

	X Axis		Axis Normal to X	
	Linear	Angular	Linear	Angular
Transfer Orbit	0		0	0
Descent Engine Operating	1.10g		$\pm .16$g	$\pm .667$ rad/sec^2
Landing - Preliminary	9.0g	± 8 r/sec^2	± 9.0g	± 24 rad/sec^2

Shock: To be supplied by Grumman.

Vibration: The mission environment consists of the following random spectrum applied for $11\frac{1}{2}$ minutes along each of three mutually perpendicular axes; X, Y and Z.

10-28 cps	.18g^2/cps Constant
28-37 cps	12 db/octave roll-off to
37-1000 cps	.059g^2/cps Constant
1000-1200 cps	12 db/octave roll-off to
1200-2000 cps	.039g^2/cps Constant

TABLE I (Continued)

Pressure:	4.8 to 5.8 psia (Oxygen) in controlled cabin $\leq 1 \times 10^{-10}$ mm of Hg in uncontrolled cabin
Temperature:	75° ± 5°F in controlled cabin (average) 50° - 90°F in controlled cabin (locally)
Humidity:	40%-70% R.H. in controlled cabin (average) 40%-100% R.H. in controlled cabin (locally)
Ozone:	To be determined.
Hazardous Gases:	Same as Prelaunch Packaged.
Electromagnetic Interference:	Same as Prelaunch Packaged.

(f) Lunar Stay

	X	Linear	Angular
Acceleration:	1/6g	0	0

Shock:	Not critical.
Vibration:	To be determined.
Pressure:	5.8 psia (oxygen) in controlled cabin. 1×10^{-6} mm of Hg in decompressed cabin.
Temperature:	75° ± 5°F in controlled cabin (average) 50° - 90° in controlled cabin (locally) -250° to +250°F on lunar surface.
Humidity:	40%-70% R.H. in controlled cabin (average) 40%-100% R.H. in controlled cabin (locally)
Ozone:	To be determined.
Hazardous Gases:	Same as Prelaunch Packaged.

TABLE I (Continued)

(g) Electromagnetic Interference: Same as Prelaunch Packaged.

Sand and Dust: To be specified by GAEC.

Lunar Ascent

Acceleration:

	X	Z	***** Linear	Angular(Y/X)	Angular(Z)
Transfer orbit	0	0	0	0	0
Maneuver	1.2g	-	$\pm$.06g	$\pm$1.25 R/sec^2	$\pm$3.23 R/sec^2
Docking	0	-4g	0	0	0

Shock: To be specified by GAEC.

Vibration: The mission environment consists of the following random spectrum applied along each of the three mutually perpendicular axes, X, Y and Z.

10-28 cps	.18g^2/cps Constant
28-37 cps	12 db/octave roll-off to
37-1000 cps	.059g^2/cps Constant
1000-1200 cps	12 db/octave roll-off to
1200-2000 cps	.031g^2/cps Constant

Pressure: 4.8 to 5.8 psia (Oxygen) in controlled cabin
1 x 10^{-10} mm of Hg in uncontrolled cabin.

Temperature: 75° $\pm$ 5°F in controlled cabin. (average)
50° to 90° in controlled cabin (locally)

Humidity: 40% to 70% R.H. in controlled cabin (average)
40% to 100% R.H. in controlled cabin (locally)

Ozone: To be determined.

- - - - - - - - - - -

*****Linear acceleration normal to X axis.

TABLE I (Cont.)

Hazardous Gases:	Same as Prelaunch Packaged.
Electromagnetic Interference:	Same as Prelaunch Packaged.

TABLE IA

ENVIRONMENTAL AND LOAD CONDITIONS

STRUCTURAL REQUIREMENTS

STRUCTURAL FACTORS OF SAFETY FOR TABLE I AND SELF-GENERATED ENVIRONMENTS

TABLE I values (mission levels)	Limit Factors for all loads due to Table I levels	Proof Factor	ULTIMATE: Ultimate Factors (Applied to limit loads) (c) (No structural failure permitted at or below this level)
Accelerations	1.0 *		1.5
Shock	1.0 *		1.5
Vibration g^2/cps	$(1.3)^2$*		$(1.5)^2$ or 2.25
Vibration g and D.A. **	1.3 *		1.5
Pressure Vessels	1.0	1.33	2.0 (p)
Pressure Fittings (Pressure Only)	1.0	2.00	3.0 (p)
Pressure Vessels	1.0 *		1.5
Acoustics (db)	1.0 *		1.0
Temperature	1.0 *		1.0 (T) 1.5 (L)
Humidity	1.0		-
Rain	1.0		-
Salt Spray	1.0		-
Sand and Dust	1.0		-
Fungus	1.0		-
Ozone	1.0		-
Hazardous gas	1.0		-
Radiation	1.0		-
Electromagnetic Interference	1.0		-
Meteoroids	1.0		-
Pressure (mm of Hg only)	1.0		-

(c) Combined loadings shall be considered.
(p) Pressure only (includes cabin, etc., excludes fuel tanks)
(T) Applies to temperature only.
(L) Applies to thermal stress/load only.
*Combined loadings (of Table I and self induced) shall be considered where applicable and when critical.
**Prelaunch Vibration limit factor = 1.0

[redacted]

Critical organ	Maximum permissible integrated dose (rem)	RBE (rem rad)	Average yearly dose (rad)	Maximum permissible single acute emergency exposure (rad)	Location of dose point *
Skin of whole body	1,630	1.4	233	500[1]	0.07-mm depth from surface of cylinder 2 at highest dose rate point along eyeline
Blood-forming organs	271	1.0	54	200	5-cm depth from surface of cylinder 2
Feet, ankles, and hands	3,910	1.4	559	700[2]	0.07-mm depth from surface of cylinder 8 at highest dose point
Eyes	271	2[3]	27	100	3-mm depth from surface on cylinder 1 along eyeline

*See figure 9

[1] Based on skin erythema level

[2] Based on skin erythema level but these appendages believed to be less radiosensitive

3 Slightly higher RBE assumed since eyes are believed more radiosensitive

TABLE II - Radiation exposure limits.

[redacted]

TABLE III

MINIMUM MOBILITY CHARACTERISTICS

SUITED CREWMAN - PRESSURIZED

FIGURE	CHARACTER-ISTIC	PGA^{W}/oPLSS	PGA + PLSS	COMMENT	MAX TORQUE (IN-LBS)
VI-1	a	$40^{\circ} (\pm 20^{\circ})$	$40^{\circ} (\pm 20^{\circ})$		
	d	120°	120°		
	g	30°	30°		
VI-2	b	120°	120°		
VI-3	c	30°	30°		25
	e	140°	140°		
VI-4	f	25°	25°		
	h	20°	20°		
VI-5	i	150°	150°		
VI-6	j	135°	135°		
	r	30°	30°		
VI-7	k	135°	135°		
	p	*155°	*155°		40
	s	30°	30°		
VI-8	l	70°	65°		
	m	5°	0°		
	q	*(75°)**(90°)	*(75°)**(90°)		70
VI-9	n	25°	25°		
	o	25°	25°		
VI-10	t	25°	20°		

* - In crouched position.

** - For climbing entry ladder.

[redacted]

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TABLE IV

ORBITAL ELEMENTS FOR MAJOR METEOR STREAMS

Name	Period of Activity	Date Max.	Normal Activity Per Hour	Ω deg.	π deg.	ω deg.	i deg.	ϵ	q a.u.	a a.u.	Velocity Geocentric Km/sec	Period - Years
Quadrantids*	Jan 2 - 4	Jan 3	80	282	92	166	57	0.46	0.97	1.7	42**	13
Lyrid	April 19 - 22	April 21	7-10	30.5	--	210	31	0.88	0.90	--	48	19.8
η - Aquarid	May 1 - 8	May 4 - 6	10-34	45	152	108	162	0.96	0.66	17.95	64	--
O - Cetid	May 14 - 23	May 14 - 23	20	238	89±3	211±3	34±7	0.91	0.11	1.3	37	1.5
Arietid	May 29 - June 19		10-80	77	106	29±3	21±8	0.94	0.09	1.6	38	1.8
ζ - Perseid	June 1 - 16		30	78	--	59±2	±2	0.79	0.35	1.6	29	2.2
β - Taurids	June 24 - July 5		20	276	162±4	246±4	±4	0.86	0.36	2.5	31	3.3
δ - Aquarid	July 26 - Aug 5	July 28	15	305	101±2	156±2	24±5	0.96	0.08	1.8	29 35**	3.6
Perseid	July 15 - Aug 18	Aug 10 - 14	50	142	--	155	114	0.96	0.97	23	60	109.5
Giacobinid*	Oct 9 - 10	Oct 10	200	196	--	172	30.8	0.72	0.99	3.5	23	6.57
Orionid	Oct 15 - 25	Oct 20 - 23	10-15	29.3	103	87.8	163	0.92	0.54	6.32	66	
Arietid, Southern	October		8	27	150	122	5	0.85	0.30	1.91	34**	2.64
Taurids, Northern	Oct 26 - Nov 22	Nov 1	4	221	160	308	2.5	0.86	0.31	2.16	36**	3.2
Taurids, Night	November		10	220	160	300	3	0.86	0.3	2.1	37**	3.3
Taurids, Southern	Oct 26 - Nov 22	Nov 16	4	45	157	112	5.1	0.85	0.36	2.39	36**	3.69
Leonid*	Nov 15 - 20	Nov 16 - 17	8-10	234	49	179	162	0.92	0.99	12.8	72	33.25
Bielids*	Nov 15 - Dec 6		20-30	250	109	223	13	0.76	0.88	3.6	16	6.6
Geminid	Nov 25 - Dec 17	Dec 12 - 13	20-60	261	--	324	24	0.90	0.14	1.4	35	1.7
Ursids	Dec 20 - 24	Dec 22	10-40	270	--	210	56±3	1.0	0.92	--	37	--

* Periodic streams
** Heliocentric velocity

NOTE: Appropriate symbols are defined in Figure 13.

[redacted]

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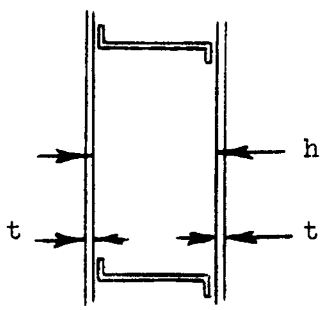
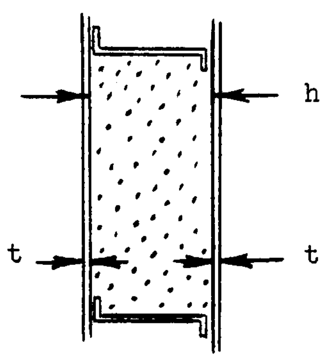
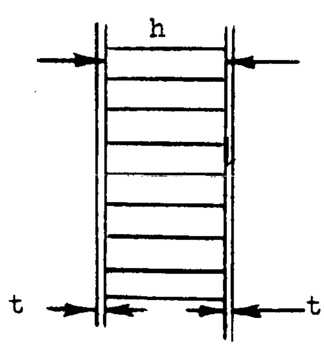
TABLE V

DOUBLE WALL EFFICIENCY FACTOR

		h	K
	NO CORE	1.0 1.5 2.0	0.50 0.35 0.20
	LOW DENSITY POROUS PLASTIC CORE	1.0 1.5 2.0	0.33 0.25 0.14
	HONEYCOMB CORE NO FILLER	1.0 1.5 2.0	0.67 0.47 0.27

K = Efficiency Factor

TABLE VI

MAXIMUM LIMITS OF SSA ATMOSPHERE CONTAMINANTS

FOR A FOUR HOUR MISSION IN THE SSA

Contaminant		Maximum Allowable Limit
Name	Formula	
Ammonia	NH_3	25 PPM
Carbon Dioxide	CO_2	7.6 mm of Hg
Carbon Monoxide	CO	25 PPM
Hydrogen	H_2	* 3%
Hydrogen Sulfide	H_2S	0.015 mm of Hg
Methane	CH_4	* 5.3%
Ozone	O_3	0.1 PPM
Water Vapor	H_2O	70% Relative Humidity

* Explosive Limits - Not to be additive

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[redacted]

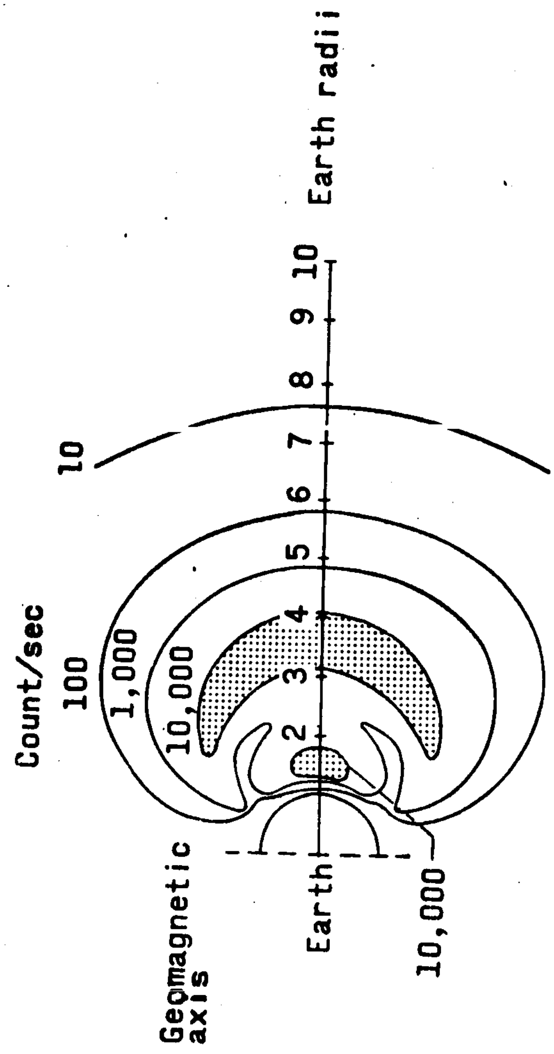

Figure 1 - Model of Van Allen radiation belts.

[redacted]

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[redacted]

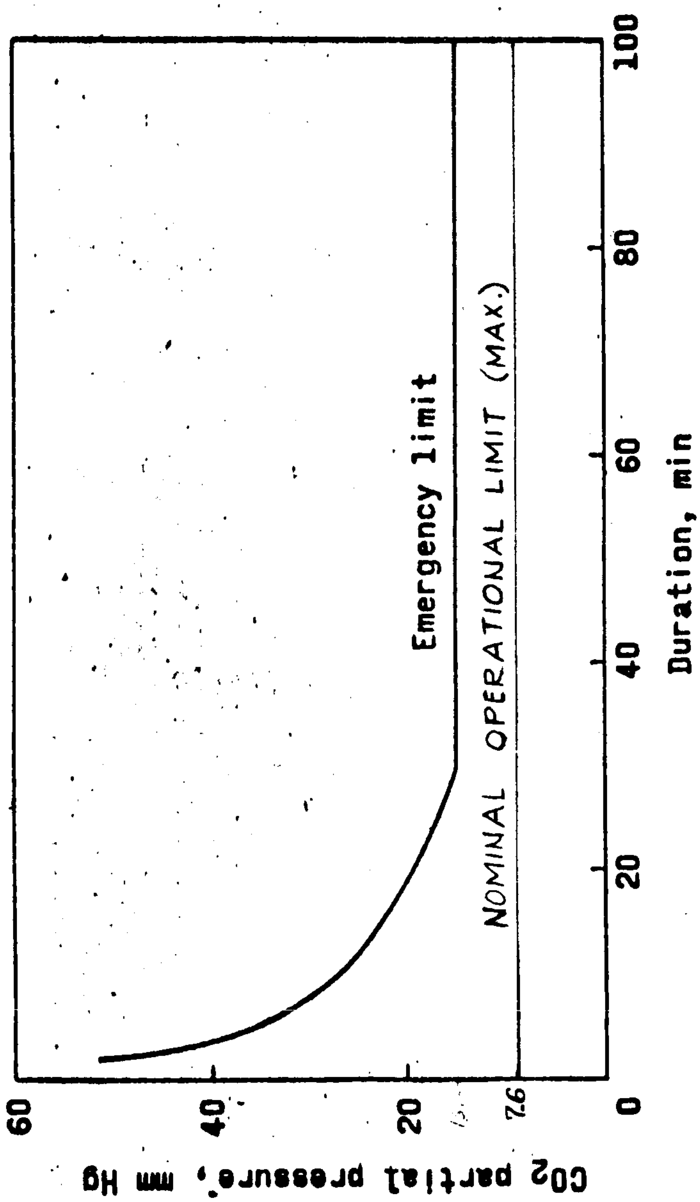

Figure 2.- Emergency carbon dioxide limit.

[redacted]

[redacted]

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[redacted]

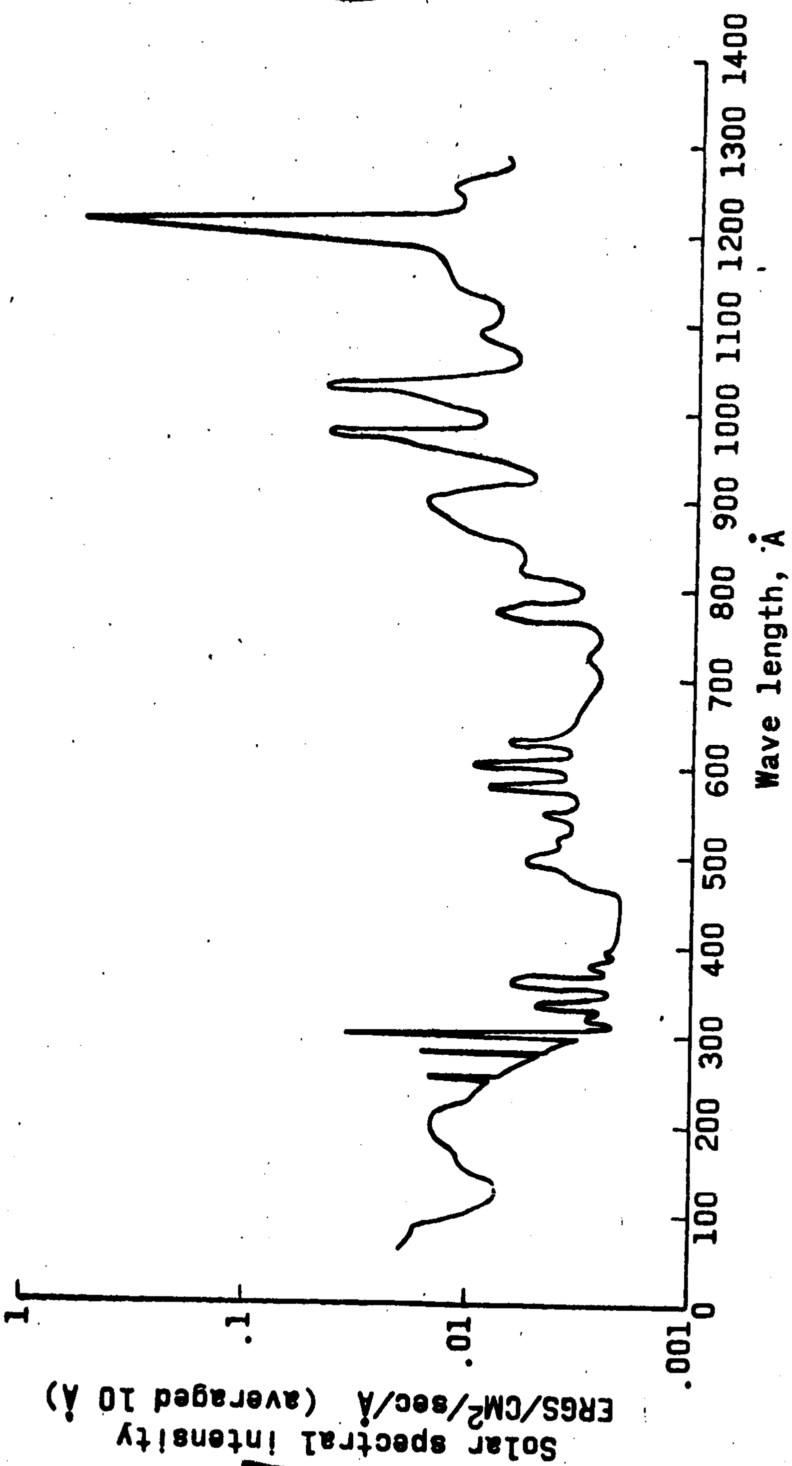

Figure 3 - Electromagnetic spectrum for solar radiation.

[redacted]

[redacted]

[redacted]

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[redacted]

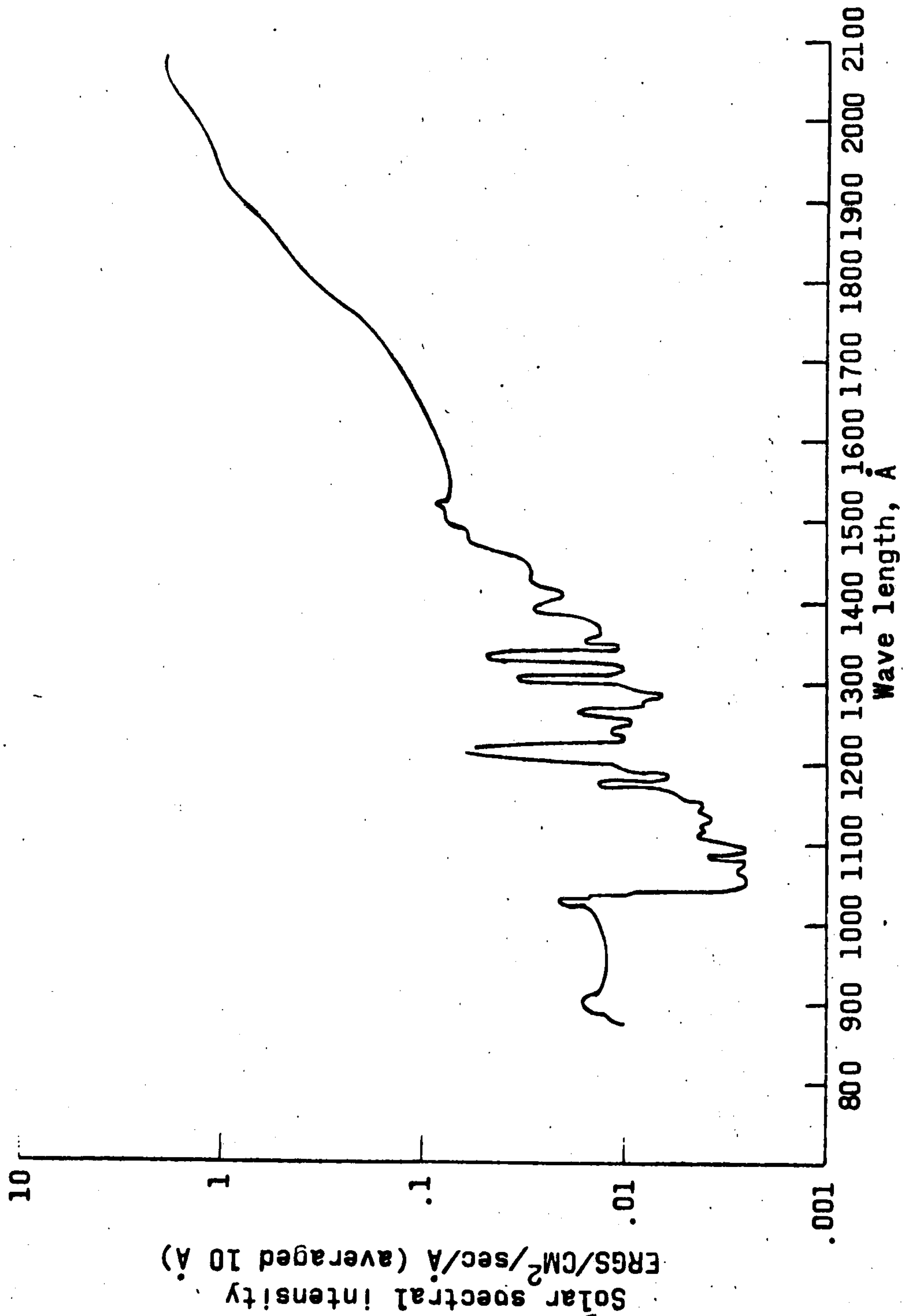

Figure 4 - Electromagnetic spectrum for solar radiation.

[redacted]

[redacted]

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[redacted]

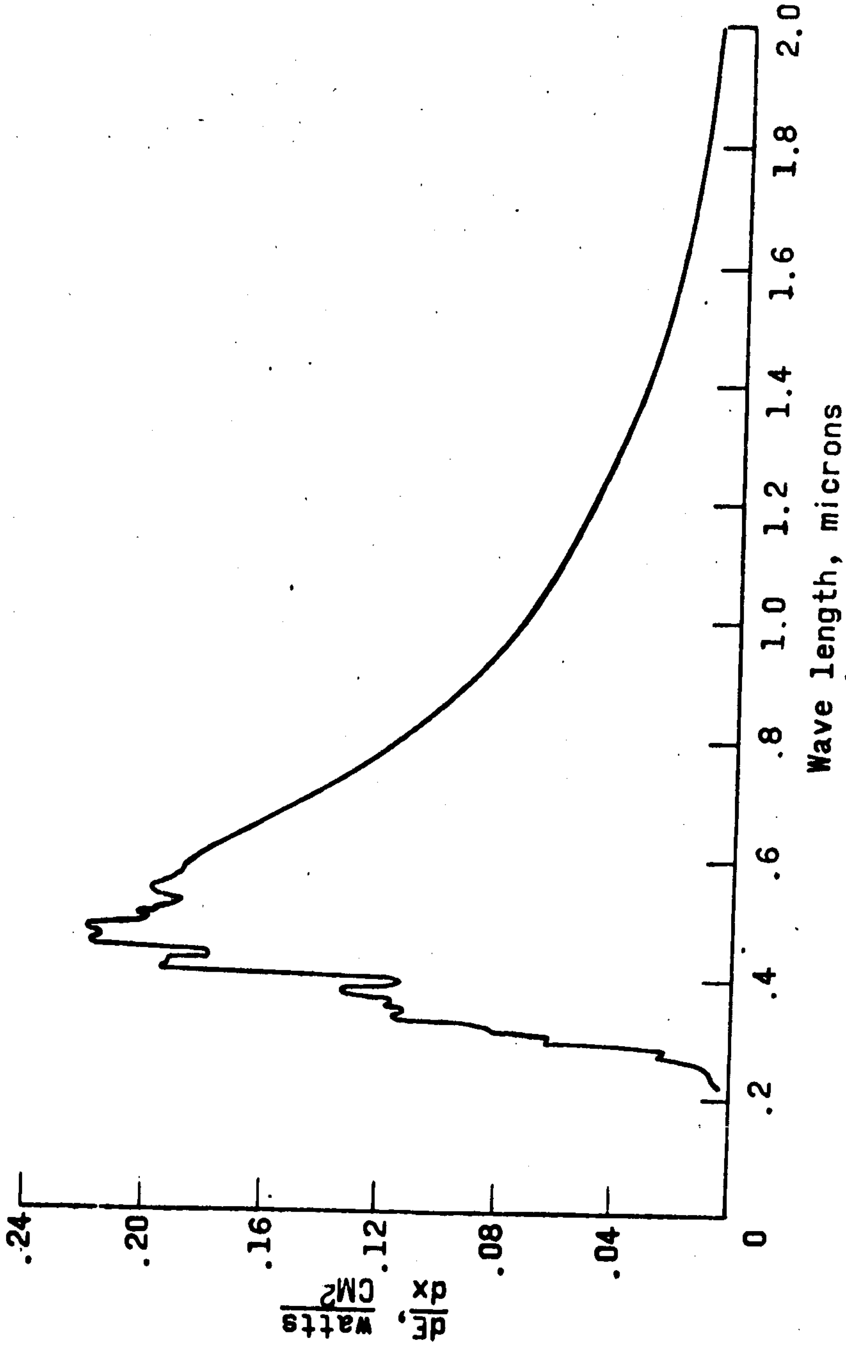

Figure 5 - Electromagnetic spectrum for solar radiation.

[redacted]

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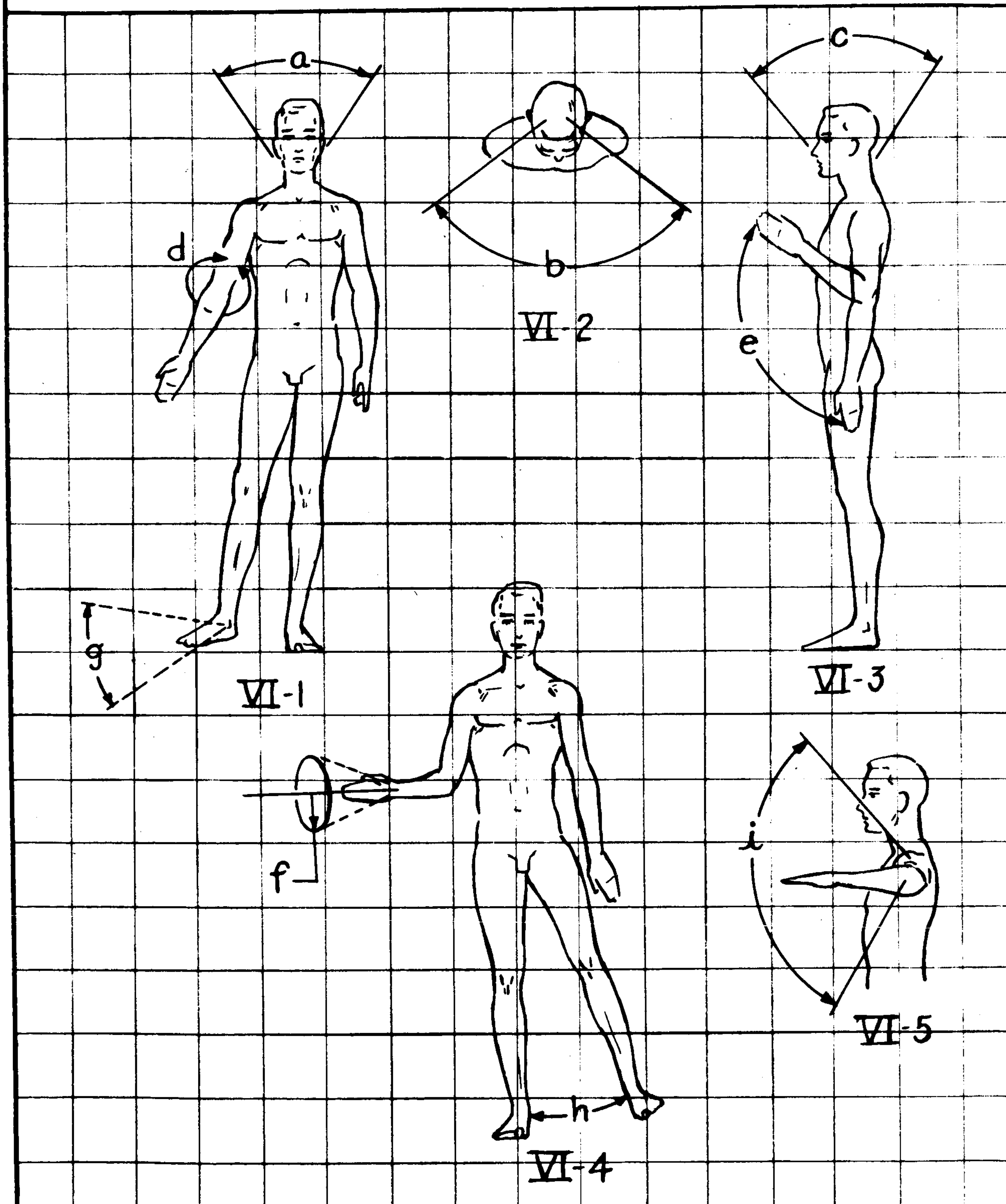
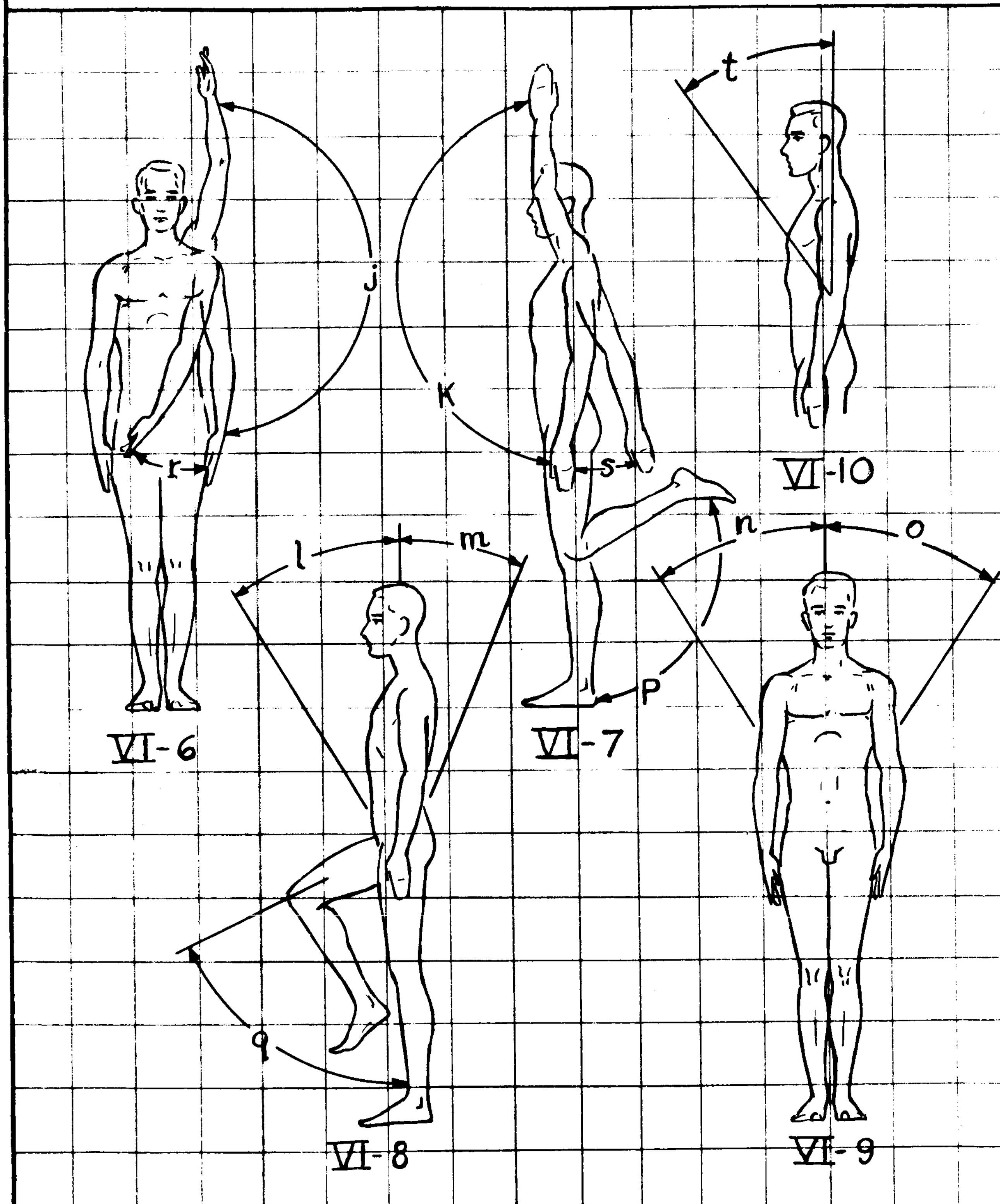
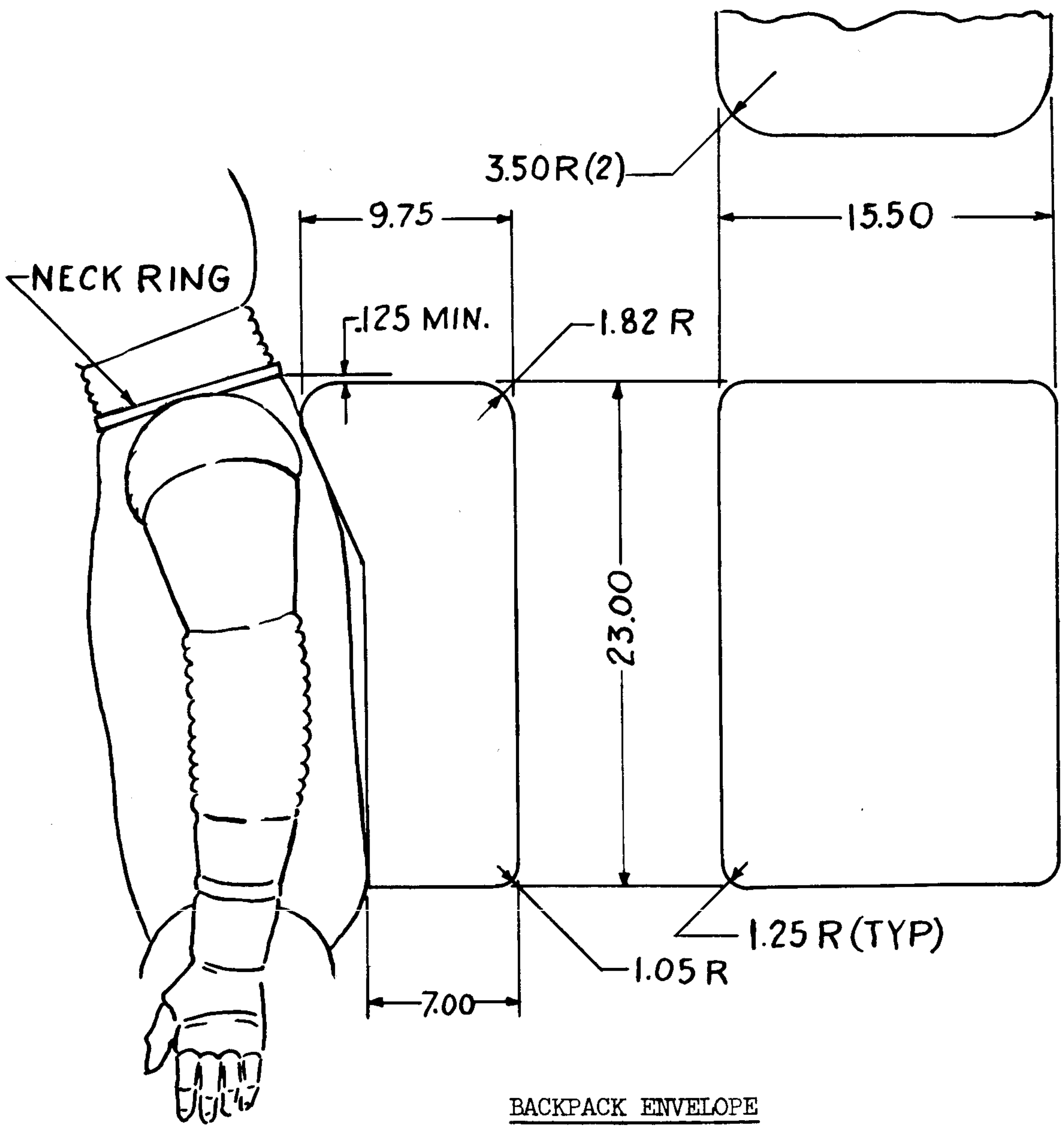


SEE TABLE III FOR VALUES FIG. 6 -A



SEE TABLE III FOR VALUES

FIG 6-B



BACKPACK ENVELOPE

FIGURE 7

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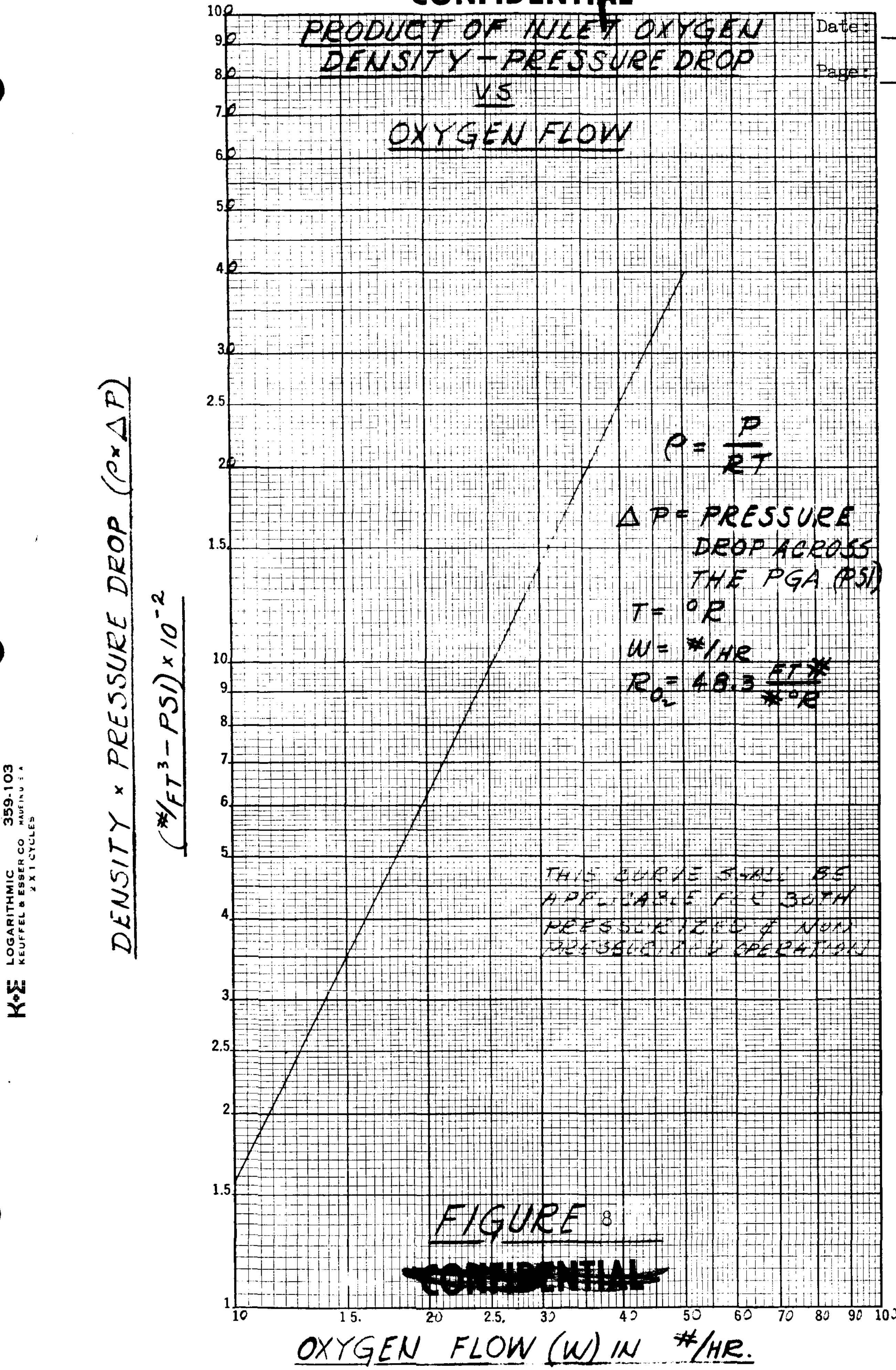

FIGURE 8

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[redacted]

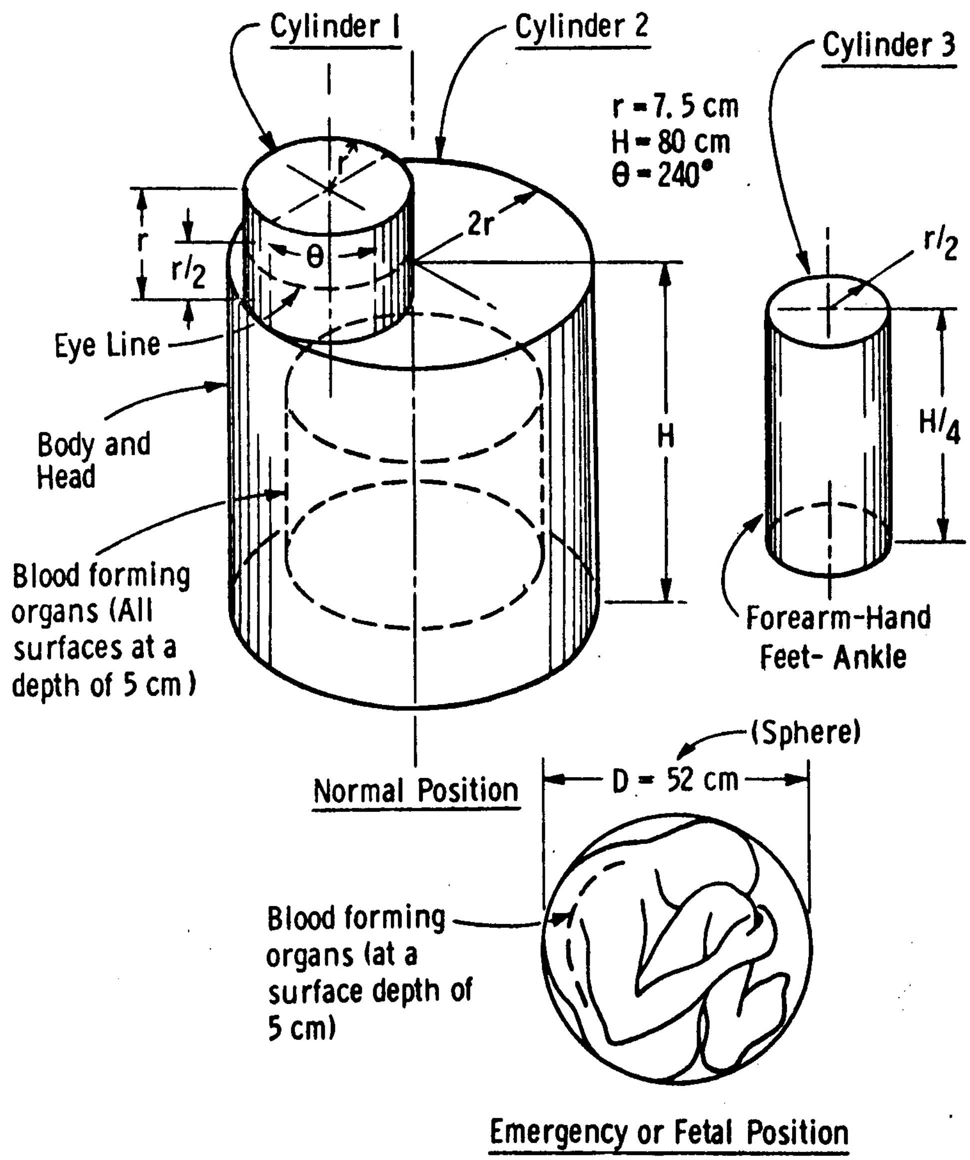
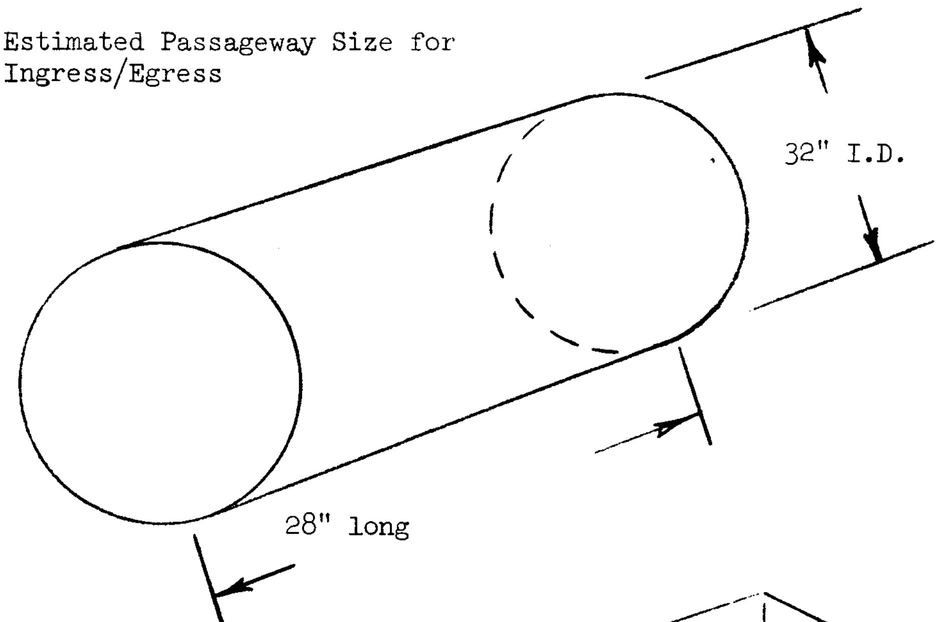


Figure 9 - Models of the radiation standard man.

[redacted]

a. Estimated Passageway Size for Ingress/Egress



b. Estimated Volume Available for Donning/Doffing

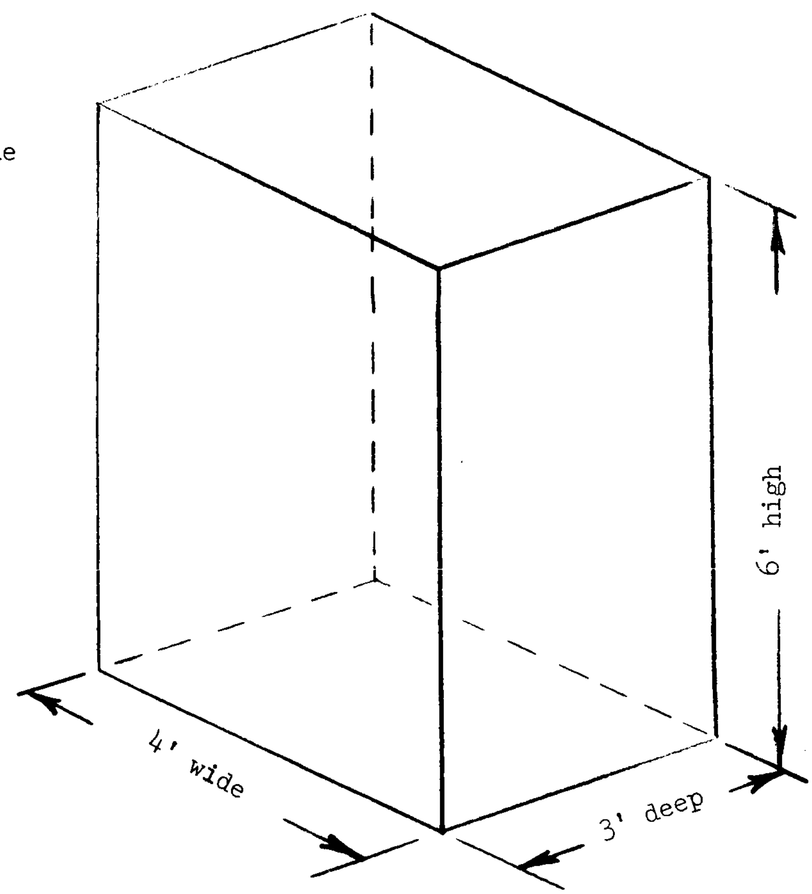
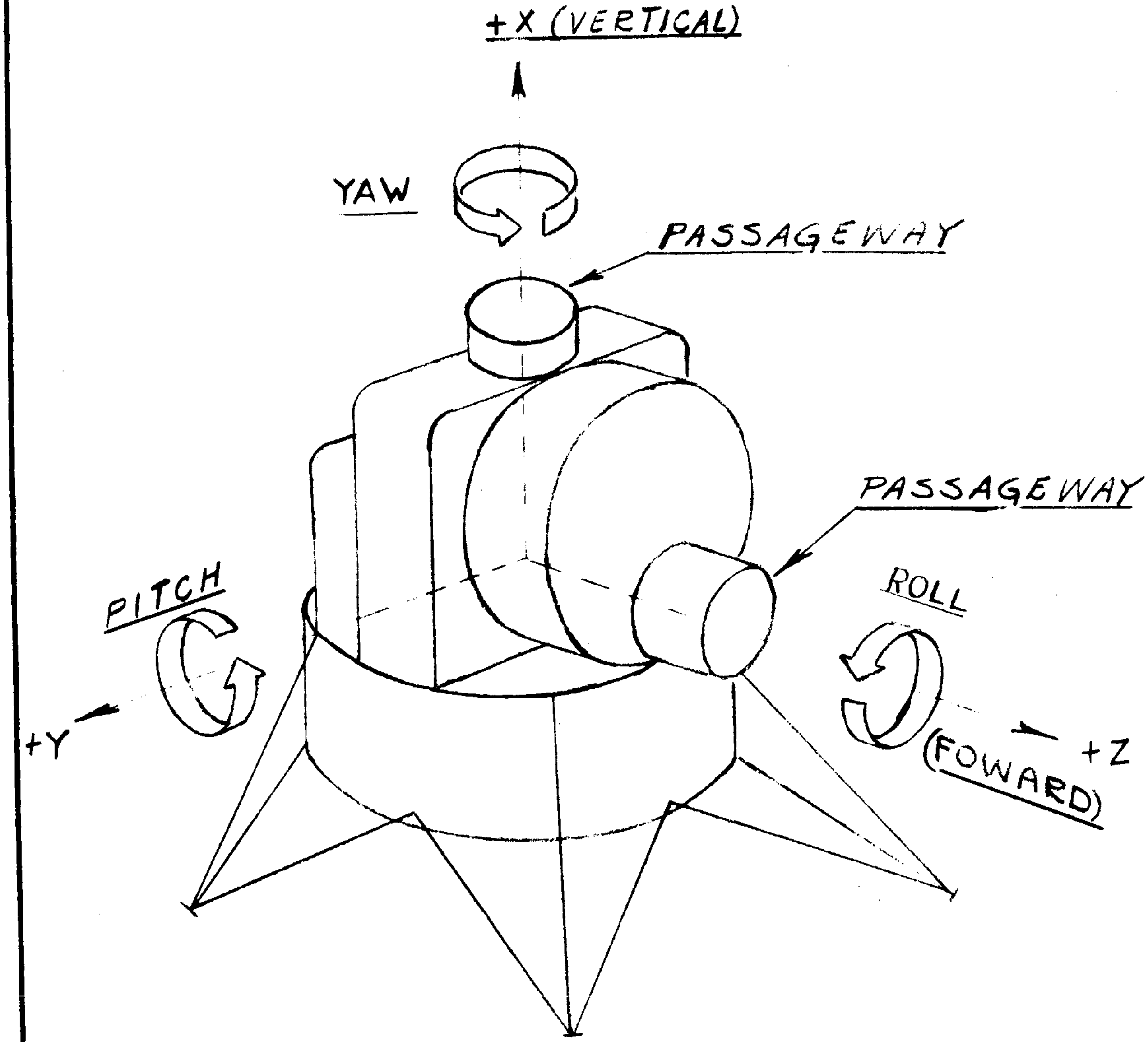


Figure 10
Estimated Don-Doff Area and Passageway Volumes



LEM COORDINATE AXES

FIGURE 11

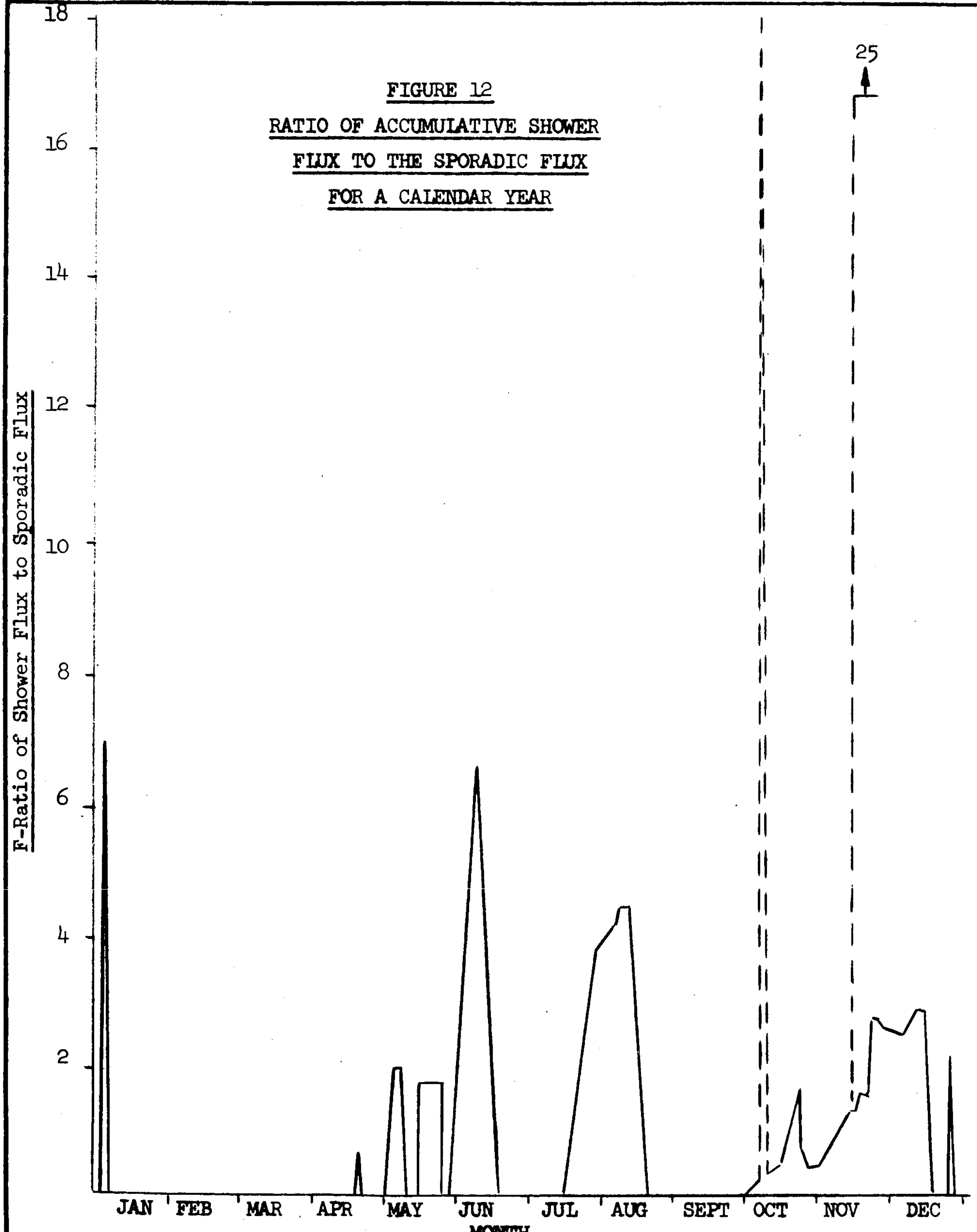


FIGURE 12

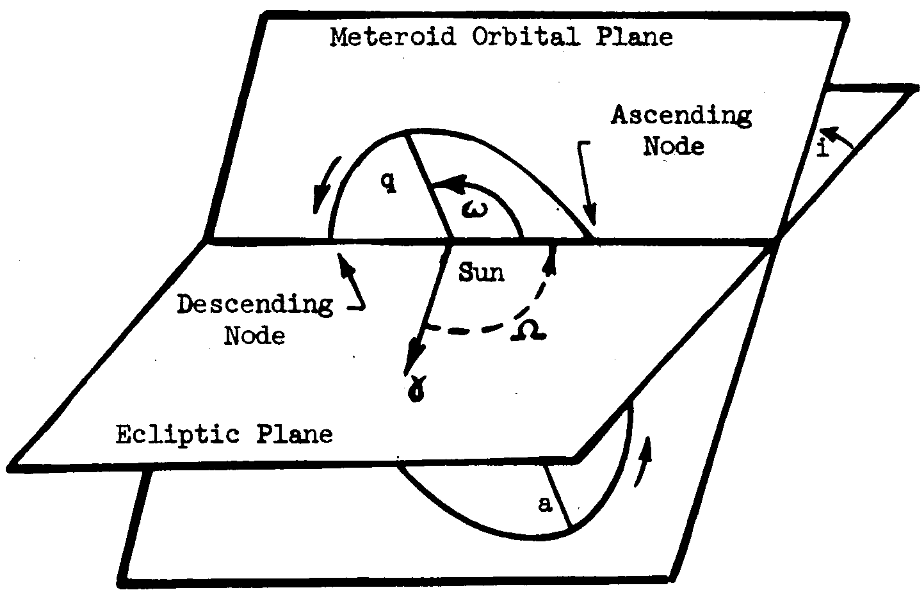
RATIO OF ACCUMULATIVE SHOWER FLUX TO THE SPORADIC FLUX FOR A CALENDAR YEAR

FIGURE 13

DEFINITION OF SYMBOLS

USED IN

TABLE IV



ϵ = Eccentricity of orbit

q = Perihelian distance (astronomical units)

a = Semi-major axis (astronomical units)

Ω = Longitude of ascending node (degrees)

ω = Latitude of perihelian (degrees)

i = Inclination of meteoroid orbital plane (degrees)

♈ = Reference point (vernal equinox)

π = Longitude of perihelian (degrees)